INSTRUCTION MANUAL

MODEL 141

VOLTAGE-CONTROLLED GENERATOR

WAVETEK

8159 ENGINEER ROAD, SAN DIEGO, CALIFORNIA

ROCKFORD INSTRUMENT LAB
DAVID A. NESHEIM
1718 BROADWAY
ROCKFORD, ILL. 61108

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VOLTAGE-CONTROLLED GENERATOR

WAVETEK
Box 651, San Diego, Calif., 714-279-2200
Box 1987, Indianapolis, Ind., 317-783-3221
Box 47, 3000 Bern 9, Switzerland, 24-11-66

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WAVETEK
Voltage Controlled
Generator VCG
Model 141
function
power
off on
freq Hz
X1K X10K
X100 X100K
X10 X1M
vernier
cal
volts p-p into 50Ω
3V 1V 3V
1V 10V
0db
-10db
-20db
0db
db
vernier
cal
50Ω
output
VCG in
sync in
sync out

SECTION 1
GENERAL DESCRIPTION

SCOPE OF MANUAL

This manual provides instructions for operating, testing, and maintaining the WAVETEK Model 141 Voltage Controlled Generator (VCG). Sections One through Six include all necessary information for maintaining the basic model. Section Seven consists of **Difference Data** that describe specific differences, if any, to the basic model.

SCOPE OF EQUIPMENT

The WAVETEK Model 141 is a wideband, voltage-controlled generator that produces precise sine ∿ , square ⊓ , and triangle ∧ waveforms over a dynamic frequency range of 0.05 Hz to 5 MHz. A six-position frequency selector switch provides a calibrated dial range from 5 Hz to 5 MHz. Frequency ranges of 100:1 and 1000:1 are provided by a vernier frequency control and a mechanical stop on the frequency dial. The frequency of the selected output waveform can be controlled remotely by a dc or sinusoidal input. The output amplitude of the selected waveform is calibrated in 10-db decrements from 10-volts peak-to-peak to 0.1-volt peak-to-peak into a 50-ohm load. Both synchronizing input and output circuits are provided.

FUNCTIONAL DESCRIPTION

The Model 141 is a closed-loop function generator (Figure 1-1) that is voltage controlled from either the front-panel frequency dial or from an external source. When the external source is a sinusoidal waveform, the selected output waveform will be frequency modulated. The closed loop consists of the VCG circuit, the integrator circuit, and the hysteresis/output switch circuit. The output of the integrator circuit is a triangle waveform that is transformed into a square waveform by the hysteresis/output switch circuit before being regeneratively applied to the input of the integrator circuit through the VCG circuit. The loop from the output of the integrator circuit to the input passes through the range selector switch that connects the proper capacitance for the selected frequency range.

The triangle waveform is also applied to the sine conversion circuit that shapes this input into a sine wave.

One of the three waveforms is then selected by a function selector switch and is applied to the output amplifier and attenuation circuit. With zero attenuation, the output waveform is 10-volts peak-to-peak into a 50-ohm load, or approximately 20-volts peak-to-peak into an open circuit. The attenuation selector switch reduces this value to 0.1 volt in 10-db decrements. The 0-db to 10-db continuous vernier attenuation knob provides intermediate values and additional attenuation for a total of –50 db. (See Output Amplitude Attenuation in Section Four.)

SPECIFICATIONS

VERSATILITY

Waveforms

Sine ∿ , square ⊓ , triangle ∧ and sync output.

Dynamic Frequency

0.5 Hz to 5 MHz.

Dial calibrated from 0.5 to 5 on the frequency dial. For voltage control of 1000:1, dial stop is at 1/100 of maximum dial; 1/1000 of maximum dial may be obtained by rotating freq vernier full ccw.

Ranges	Dial
X10	0.5 Hz to 50 Hz
X100	5 Hz to 500 Hz
X1K	50 Hz to 5 kHz
X10K	500 Hz to 50 kHz
X100K	5 kHz to 500 kHz
X1M	500 kHz to 5 MHz

Outputs

Main output ∿ , ⊓ or ∧ selectable. Maximum amplitude approximately 20 V p-p into an open circuit with calibrated 10 V p-p into a 50-Ω load. Precision output attenuator in 10-db steps and 10-db vernier giving overall attenuator capability of greater than 50 db. Output impedance is 50 Ω. Short circuit output current ±100 mA.

Sync Output

Positive and negative pulses coincident with the positive and negative transitions of the square wave.

VCG—Voltage Controlled Generator

Up to 1000:1 frequency change with external voltage

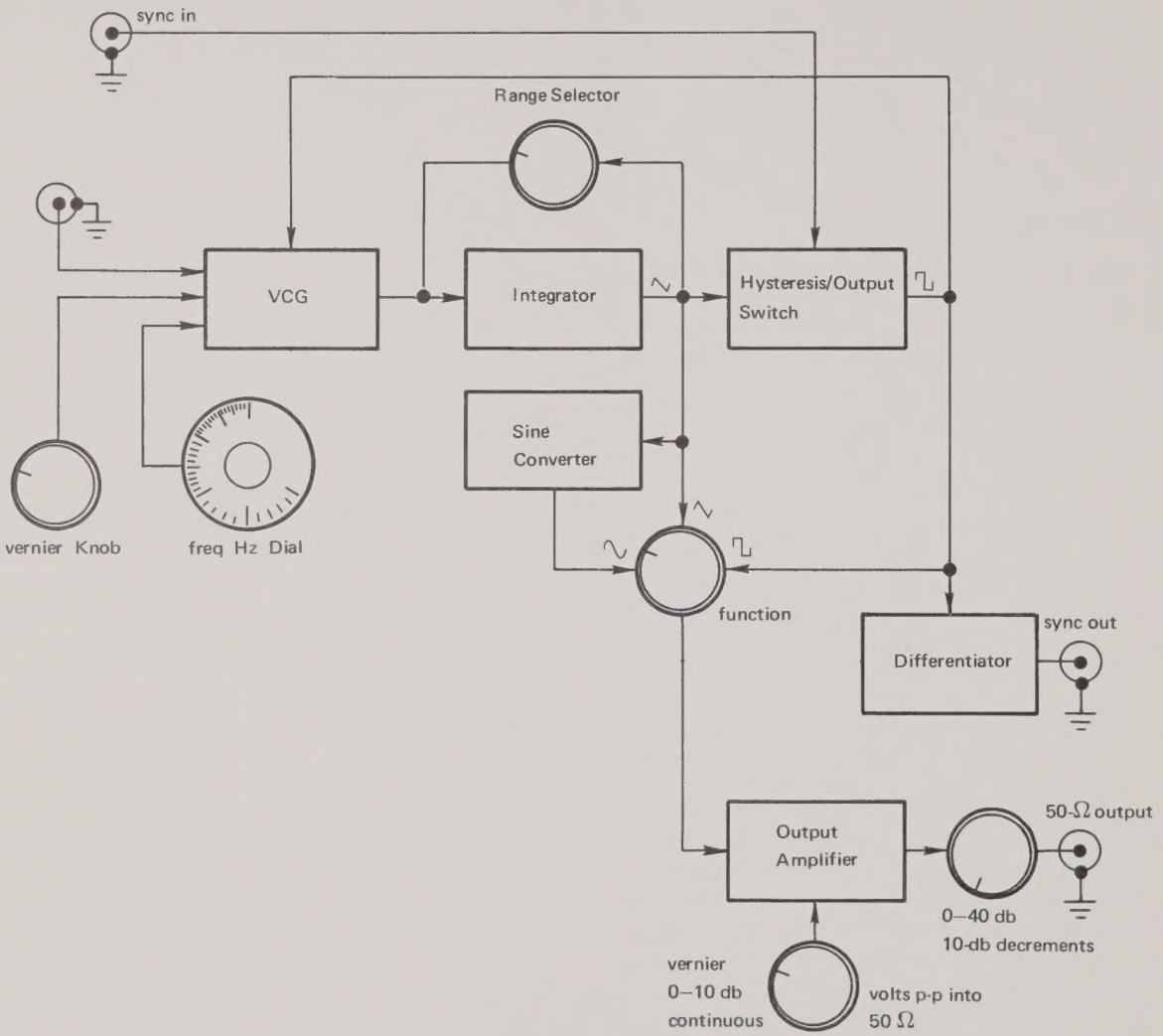

Figure 1-1. Simplified block diagram.

input. (Note: Upper frequency limited to maximum of dial range.) Required external signal for full voltage control is 2.5 volts. VCG input impedance is 50 Ω.

HORIZONTAL PRECISION

Dial Accuracy

±1% of full scale to 500 kHz,
±3% of full scale to 5 MHz.

Electronic Frequency Vernier

Note: Dial is a high-quality composition potentiometer allowing true continuously variable frequency control.

Typical VCG Linearity

±0.1% output frequency-vs-input voltage (best straight-line method) over 0.5 to 5 times frequency range setting.

Frequency vs input voltage—best straight-line method.

VCG Bandwidth

Less than 3 db down at 100 kHz useable to 1 MHz.

Sync Input

Instrument may be synchronized to an external signal that is at least 5 V p-p. Model 141 frequency must be within 1% of input frequency for lock to occur. A slight change in triangle and sine amplitude occurs when locked. Induced sine distortion less than 1%.

Frequency Amplitude and DC Offset Stability

Short term: Drift less than ±0.05% of setting for 10 min.
Long term: Drift less than ±0.25% of setting for 24 hr.
No critical components requiring internal oven.

Jitter

±0.025% cycle-to-cycle stability to 1 MHz.

VERTICAL PRECISION

Frequency Response

Sine and square outputs—Amplitude change with frequency less than 0.1 db to 500 kHz and 0.5 db to 5 MHz.

Triangle output—Amplitude change with frequency less than 0.1 db to 500 kHz, and 1.0 db to 5 MHz.

Peak-to-Peak Voltage Accuracy

±1% for sine, square, and triangle output, reference 5 kHz, 0 and −10 db setting ±3% reference 5 kHz, −20, −30, and −40 db settings.

Symmetry

All waveforms are symmetrical about ground within ±1% of maximum p-p amplitude (zero adjust rear-panel control).

PURITY

Sine Wave Distortion

Less than:
0.5% to 5 kHz
1.0% to 50 kHz
2.0% to 500 kHz
500 kHz to 5 MHz. All harmonics at least 30 db down.

Triangle Linearity

Greater than:
99% to 100 kHz
95% to 5 MHz

Square Wave Rise and Fall Time

Less than 30 nsec.

Total Aberrations

Less than 5%

Time Symmetry

All waveforms:
99.5% to 500 kHz
99% to 5 MHz

ENVIRONMENTAL

Temperature

All specifications listed, except stability, are for 25°C ±5°C.

For operation from 0°C to 55°C derate all specifications by a factor of 2.

MECHANICAL

Dimensions:

7¾ inches wide, 5¼ inches high, 11½ inches deep.

Weight

7 lb net, 10 lb shipping.

Controls

Power on/off switch, frequency range switch, frequency vernier, function selector switch, amplitude attenuator, amplitude vernier. Rear-panel dc zero adjustment.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz; less than 10 watts.

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SECTION 2
OPERATION

INTRODUCTION

The Model 141 is a versatile instrument capable of many diversified applications in any of the many disciplines using electronic waveforms for their unique applications. This section provides basic instructions for using the instrument as a function generator, a signal generator, or a voltage-controlled generator over the dynamic frequency range of 0.05 Hz to 5 MHz. The instructions do not attempt to list all of the many possibilities available with this instrument.

CONVERSION FOR 230-VOLT LINE POWER

The Model 141 is shipped from the factory with the power transformer connected for 115-volt line power unless otherwise ordered. To convert the transformer primary for 230-volt operation, refer to Section Six for instructions on gaining access to the Amphenol pin connectors and then follow these procedures:

1. Cut the jumper between Amphenol socket No. 13 and 14.
2. Cut the jumper between Amphenol socket No. 11 and 12.
3. Connect a jumper between Amphenol socket No. 11 and 14 (black/white and gray transformer leads).

OPERATING CONTROLS

Figure 2-1 shows all of the operating controls and indicators for the Model 141, and Table 2-1 provides a concise functional description of these devices.

RECEIVING INSPECTION

The following procedures should be performed to assure the user that the instrument has arrived at its destination in proper operating condition. Complete calibration and checkout instructions are provided in Section Four for determining that the instrument is within electrical specifications.

Visual Inspection

After carefully unpacking the equipment, visually inspect the external parts for damage to knobs, dials, indicators, surface areas, etc. If damage is discovered, file an approved claim with the carrier that transported the instrument.

Operating Inspection

The procedural steps in this subparagraph provide a quick checkout of instrument operation. If electrical deficiencies exist, refer to the Warranty in the front of this manual. The following test equipment, or equivalent, is recommended for performing the electrical inspection.

Name	Manufacturer	Model
Oscilloscope	Tektronix	543B
Plug-in unit	Tektronix	W or Z

To perform the electrical inspection, proceed as follows:

1. Turn *power* switch to *on*; wait 5 minutes for warmup.
2. Connect oscilloscope, with 50-ohm terminator, to *50-ohm output* connector.
3. Set *volts p-p into 50Ω* selector at *10V*; rotate *vernier* knob to *cal*.
4. Set *freq Hz* selector to *X1K*; rotate *vernier* knob to *cal*.
5. Set *freq Hz* dial to *2.5*.
6. Progressively set *function* selector to ∿ , ∩ , and ⊓ ; observe display for these waveforms, without appreciable change in amplitude during switching.
7. Progressively set *volts p-p into 50Ω* selector through its five positions and observe for the following peak-to-peak voltage levels: 10 volts, 3.16 volts, 0.316 volt, and 0.1 volt.
8. Reset the *volts p-p into 50Ω* at *10V* and rotate the *vernier* knob to maximum counterclockwise stop. Amplitude should decrease to 3 volts, or less.
9. Reset *volts p-p into 50Ω* at *10V*. Progressively set *freq Hz* selector at each of its six positions from *X10* to *X1M* and check for the following frequencies: 25 Hz, 250 Hz, 2.5 kHz, 25 kHz, 250 kHz, and 2.5 MHz.

Table 2-1. OPERATING CONTROLS, CONNECTORS, AND INDICATORS

Name	Function
function selector	Selects output waveform: ∿ , ⊓ , or ⩘ .
freq Hz selector	Selects frequency multiplier: *X10, X100, X1K, X10K, X100K,* or *X1M.*
freq Hz dial	Selects calibrated frequency from *.5* to *5* for all ranges. In *.05* position, dial functions in conjunction with *vernier* knob CCW position and *freq Hz* selector position *X10* to extend uncalibrated low-frequency range to 0.05 Hz.
vernier knob	Provides continuously-variable vernier frequency control.
power switch	Connects ac line power to Model 141 power supply.
volts p-p into 50 Ω selector	Selects output attenuation in 10-db decrements from 0 db to −40 db.
vernier knob	Adds continuously-variable output attenuation from 0 db to −10 db to setting of *volts p-p into 50 Ω* selector.
	Connectors
VCG in	Connects external voltage control to Model 141 VCG.
sync in	Connects external sync source to Model 141.
sync out	Connects sync pulse, at selected frequency, to external device.
50 Ω output	Connects selected output waveform to external device.
	Indicators
Frequency index marker	Illuminates when Model 141 *power* switch is in the *on* position.

10. Reset *freq Hz* selector to *X10K*. Progressively rotate *freq Hz* dial from *5* to *.05* and check frequency at each numbered dial division for the following respective frequency measurements over the 100:1 frequency ratio: 50 kHz, 40 kHz, 30 kHz, 20 kHz, 10 kHz, 5 kHz, 0.5 kHz.
11. With the *freq Hz* dial at *.05* rotate the *vernier* knob to its maximum counterclockwise position; the output frequency should decrease to 0.05 Hz, or less, indicating the 1000:1 frequency ratio capability of the instrument.
12. Set the *freq Hz* dial to *.5* and *vernier* to *cal*. Inject +1.000V into *VCG in* connector and check that the frequency increases from 5 kHz to 15 kHz. After checking, disconnect the external voltage source.

OPERATION AS A FUNCTION GENERATOR

Calibrated Operation

To operate the Model 141 for a calibrated 5 Hz to 5 MHz output, proceed as follows:

1. Properly terminate the *50 Ω output* with the device requiring the input signal.
2. Set the *volts p-p into 50 Ω* to the desired attenuation setting: *0 db, −10 db, −20 db, −30 db,* or *−40 db.*

Note: For calibrated output, the *vernier* dial must be

Figure 2-1. Model 141 front panel operating controls.

set to the *cal* index.

3. Set the *function* selector to the desired waveform: ∿ , ⊓ , or ∿ .
4. Set the *freq Hz* selector to the desired frequency multiplier setting: *X10, X100, X1K, X10K, X100K,* or *X1M*.

Note: The *vernier* knob must be set to the *cal* index.

5. Rotate the *freq Hz* dial until the desired dial mark (*0.5* to *5*) is aligned with the dial index.
6. Place the *power* switch in the *on* position.

Note: Allow 15 minutes for warmup time.

Uncalibrated Operation

The frequency range of the Model 141 can be extended from 5 Hz to 0.05 Hz in uncalibrated operation by following the previous instructions with the following exceptions:

1. Set the *freq Hz* selector to the *X10* setting.
2. Set the *vernier* dial to its maximum counterclockwise position.
3. Set the *freq Hz* dial to *.05* setting. The output frequency will be 0.05 Hz at this setting and increased to 5 Hz as the dial is rotated to the *.5*

position.

Note: If an electronic counter is available, the output frequency may be accurately set over this range.

Synchronized Operation

The Model 141 can be synchronized to an external waveform (sine, square, trapezoid, or triangle) by following the previous instructions with the following exceptions:

1. Connect the synchronizing signal to the *sync in* connector on the front panel.
2. Set the output frequency of the Model 141 to within ±1 percent of the synchronizing signal frequency.

OPERATION AS A FREQUENCY MODULATED GENERATOR

Positive Sweep Operation at 1000:1 Frequency

To sweep the selected output waveform at a 1000:1 (maximum) frequency ratio, perform the **Calibrated Operation** instructions with the following exceptions:

1. Set the *freq Hz* dial to *.05*.
2. Set the *vernier* dial to its maximum counterclockwise position.
3. Connect a 50-ohm signal source of +5-volts peak to the *VCG in* connector on the front panel. The frequency of the waveform output will vary from the lowest frequency (as determined by the *freq Hz* selector setting) to X1000f at a rate that is equal to the frequency of the signal source.

Negative Sweep Operation at 1000:1 Frequency Ratio

To sweep the selected output waveform at 1000:1 (maximum) frequency ratio, perform the **Calibrated Operation** instructions with the following exceptions:

1. Set the *freq Hz* dial at *5*.
2. Set the *vernier* control to the the *cal* index.
3. Connect a 50-ohm signal source of –5-volts peak to the *VCG in* connector. The frequency of the output waveform will vary from the highest frequency (as determined by the *freq Hz* selector setting) to 0.001f at a rate that is equal to the frequency of the signal source.

Symmetrical Sweep Operation at 1000:1 Frequency Ratio

To sweep the selected output waveform symmetrically at a 1000:1 (maximum) frequency ratio, perform the **Calibrated Operation** instructions with the following exceptions:

1. Set the *freq Hz* dial at *2.5*.
2. Set the *vernier* knob to the *cal* index.
3. Connect a 50-ohm signal source of 5-volts peak-to-peak to the *VCG in* connector. The frequency of the output waveform will vary symmetrically about the center frequency (as determined by the *freq Hz* selector setting) at a rate that is equal to the frequency of the signal source.

Note: The 1000:1 frequency ratio is not applicable on the 1 MHz setting.

SECTION 3
CIRCUIT DESCRIPTION

GENERAL THEORY

Generator Function

The closed-loop functional details of the Model 141 are shown in the block diagram in Section Six. The two integrators and the hysteresis and output switch combine to form the regenerative operation of the loop. When operation begins, the output of the selected integrator rises linearly until it reaches 1.25 volts which is the excursion limit for the hysteresis and output switch. This circuit functions as a Schmitt trigger, with limit points set at +1.25 and −1.25 volts to drive a bistable switch.

The hysteresis and output switch fires at the upper limit, reversing output direction and, since this output is returned to the input of the integrator, the triangle output of this circuit also reverses direction. When the triangle waveform reaches −1.25 volts, a second reversal takes place. The result is simultaneous generation of a square wave and a triangle wave of the same frequency and with the negative-going edge of the square wave coincident with the positive peak of the triangle wave.

The frequency of the waveforms is determined internally by the combined setting of the *freq Hz* range selector and frequency dial, or externally by the setting of these controls and the level of the external dc or sinusoidal voltage applied at the *VCG in* connector. The square wave determines the direction of current in the integrating capacitor. When voltage is maximum, the integrating current is maximum, resulting in maximum frequency for any selected *freq Hz* range setting.

The *freq Hz* range selector connects the correct capacitive combination into the feedback path of one of the integrators to provide the proper charging rate for the indicated frequency range. Two integrators are required in this instrument because of the wide frequency range. Although the X10 to X100K integrator amplifier has a very good slew rate (approximately 20 V/μsec , a 200 V/μsec slew rate is required from the X1M integrator.

The hysteresis/output switch functions as a Schmitt trigger driving a bistable switch. When the triangle waveform output from the integrator reaches +1.25 volts, the Schmitt trigger produces a negative pulse that turns on the section of the bistable switch that provides the positive 5-volt half-cycle of the square wave. Conversely, when the triangle waveform reaches the −1.25-volt limit, the Schmitt trigger produces a positive pulse which turns on the section of the bistable switch that provides the negative 5-volt half-cycle of the square wave. The combined output of the bistable then becomes a 10-volt peak-to-peak square wave signal.

Frequency Control

As previously mentioned, the frequency of the square waveform, within any selected frequency setting, is determined by the amplitude of the externally or internally applied voltage. This input voltage is applied to the first VCG amplifier which, in turn, is connected to the second VCG amplifier (Fig. 3-1). These amplifiers provide a very linear transformation of the input current into output current. Since the amplifiers are cascade-connected, their respective outputs are of opposite polarity. When operated with internal frequency control and with the *freq Hz* dial at its maximum clockwise setting (+5.75 volts), the first output is −5 volts and the second output is +5 volts. The output current of the second VCG amplifier is twice that of the first VCG amplifier. When the square wave is negative, only the first VCG amplifier provides current to the integrator. When the square wave is positive, the output of the second VCG amplifier is connected to the integrator. The second VCG amplifier provides twice as much current of opposite polarity as the first VCG amplifier: the integrator input is the algebraic sum of the two currents when the square wave is positive. Decreasing the frequency setting to a lower voltage value decreases the RC slope gradient and therefore, decreases the output frequency.

Synchronizing Input and Output

The selected waveform output of the Model 141 can be synchronized to an external sine wave of the same frequency as the selected output waveform frequency.

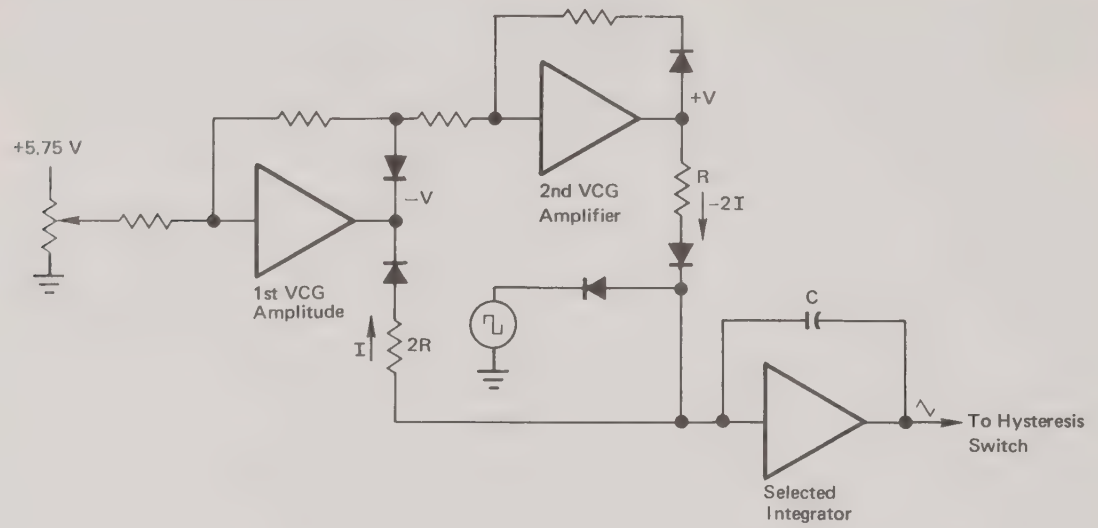


Figure 3-1. Frequency control, simplified diagram.

The sinusoidal input signal is transformed into a trapezoidal waveform by a limiter circuit. The trapezoid is then applied to the input to the Schmitt trigger in the hysteresis/output switch circuit, resulting in a shifting of the firing points for this circuit to provide synchronization.

The synchronizing output pulse is obtained by passing the square wave through a pnp emitter follower and RC differentiating network. The emitter follower is turned on by the trailing edge of the positive half-cycle and the following differentiating network transforms the pulse into positive and negative spikes.

Sine Wave Conversion

Sine-wave conversion is obtained by using a clipper to transform the triangle wave into a trapezoidal wave and then transforming this waveform into a precise sine wave by the linear approximation method, Fig. 3-2. Clipping is accomplished by a diode-bridge dc clamping integrated circuit that removes the upper and lower peaks from the triangle wave. The output of the clipper feeds four diode-resistor networks which are successively connected into the circuit as the signal level increases, with the resulting shaping of the trapezoid into a sine wave.

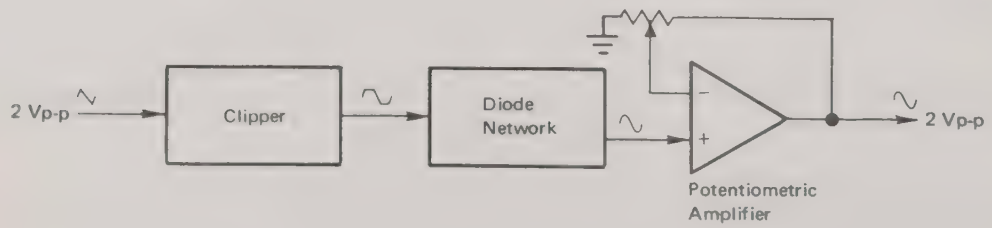


Figure 3-2. Sine-wave conversion, simplified diagram.

Because of inherent loss in the diode-resistor circuitry, the shaped sine wave is then applied to a potentiometric amplifier having the necessary gain to increase the input signal to the required 2-volts peak-to-peak amplitude at the input of the power amplifier.

Output Amplifier and Attenuation

The power amplifier is a potentiometric amplifier with attenuation preceding and following the amplifier (see Fig. 3-3). The potentiometric amplifier provides precise adjustment of the output level and offset, an approximate 1000 V/μsec slew rate, and the necessary gain to drive the 50-ohm coaxial output. The selected waveform is applied to the first section of the attenuator selector from the waveform selector on the Main Board. The first section of the attenuator selector provides zero attenuation in the first wiper position or 10 db of attenuation in each of the other four positions.

The output of the first switch section is connected through a 0-db to 10-db variable attenuator to the potentiometric amplifier. Between the amplifier output and the 50-ohm coaxial connector is the second switch section. In wiper positions 3, 4, and 5, this section cummulatively adds 10, 20, and 30 db of attenuation, respectively, to the –10 db of the first switch section and the variable attenuation setting of the vernier control. Thus, any desired attenuation from 0–50 db is available with the Model 141.

Power Supply and Regulation

Regulated operating voltages for the solid-state devices of the Model 141 are +6, –6, +12, –12, +27, and –27 volts dc. The 115-volt line power is connected through the power cord to the *power* switch on the subpanel. A ¾-ampere fuse is installed on the line side of the switch. (See Mother Board schematic diagram in Section Six.)

When the switch is in the *on* position, a chassis-mounted transformer provides the proper ac potentials for two full-wave bridge rectifiers on the Mother Board. One rectifier provides 15-volts dc, and the other 30-volts dc. These unregulated voltages are then connected to the Power Regulator Board.

All regulated outputs from the power regulator are referenced to +6 volts (Fig. 3-4). The +15 unregulated voltage from the rectifier is passed through a series regulator and then applied to a transistor connected as a Zener diode regulator (Q_Z). The nominal 6.7-volt output of the Zener is then converted into regulated +6 volts by a potentiometric amplifier (Reg 1) that performs the necessary error sensing and regulation. The output of Regulator 1 is then inverted, error sensed, and regulated to provide the regulated –6 volts by the following operational amplifier.

Regulators 3 and 4 similarly transform the +15

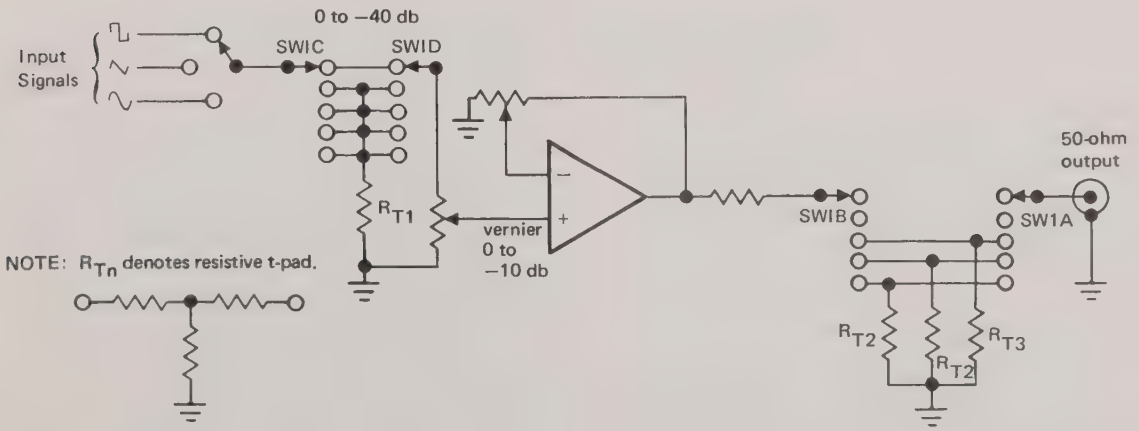


Figure 3-3. Output amplifier and attenuation, simplified diagram.

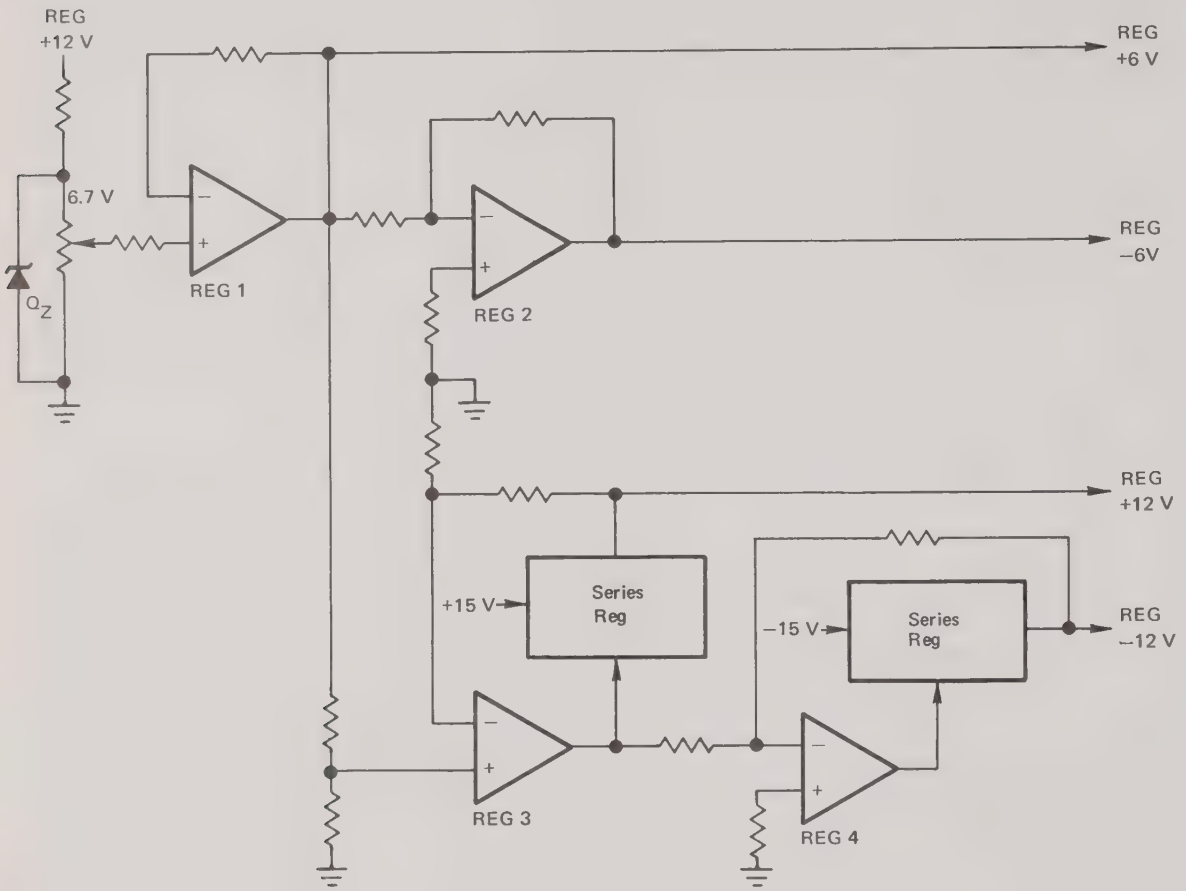


Figure 3-4. Power regulator, simplified diagram.

unregulated voltage into +12 volts and −12 volts. Because of the higher voltage, conventional series regulators are used. The regulated +27 volts and −27 volts are obtained from the unregulated +30 volts and −30 volts, respectively, and by circuits that are very similar to Regulators 3 and 4.

DETAILED CIRCUIT DISCUSSION

The schematic diagrams referenced in the following circuit descriptions are contained in Section Six. Interconnections between the different boards are shown on the Subpanel Board and Mother Board schematic diagrams. The latter diagram also includes electrical parts that are mounted on the chassis assembly.

Voltage-Controlled Generator

The Model 141 VCG circuitry provides a very linear transformation of input current to output voltage over the 0-volt to 5.75-volt range. The 0-volt to 2.5-volt input for controlling the frequency from an external source is applied through the *VCG in* connector on the front panel (see Fig. 3-5). The applied voltage may be either dc or sinusoidal, if frequency modulation is desired.

The internal voltage control consists of the *freq Hz* dial (R4) and the *vernier* knob (R90). The control voltage is applied to the inverting input (pin 3) of integrated circuit IC1, which is shown in detail on the Main Board schematic diagram. The *freq Hz* dial and range selector combine to provide a calibrated frequency range from 5 Hz to 5 MHz when the *vernier* knob is in the *cal*

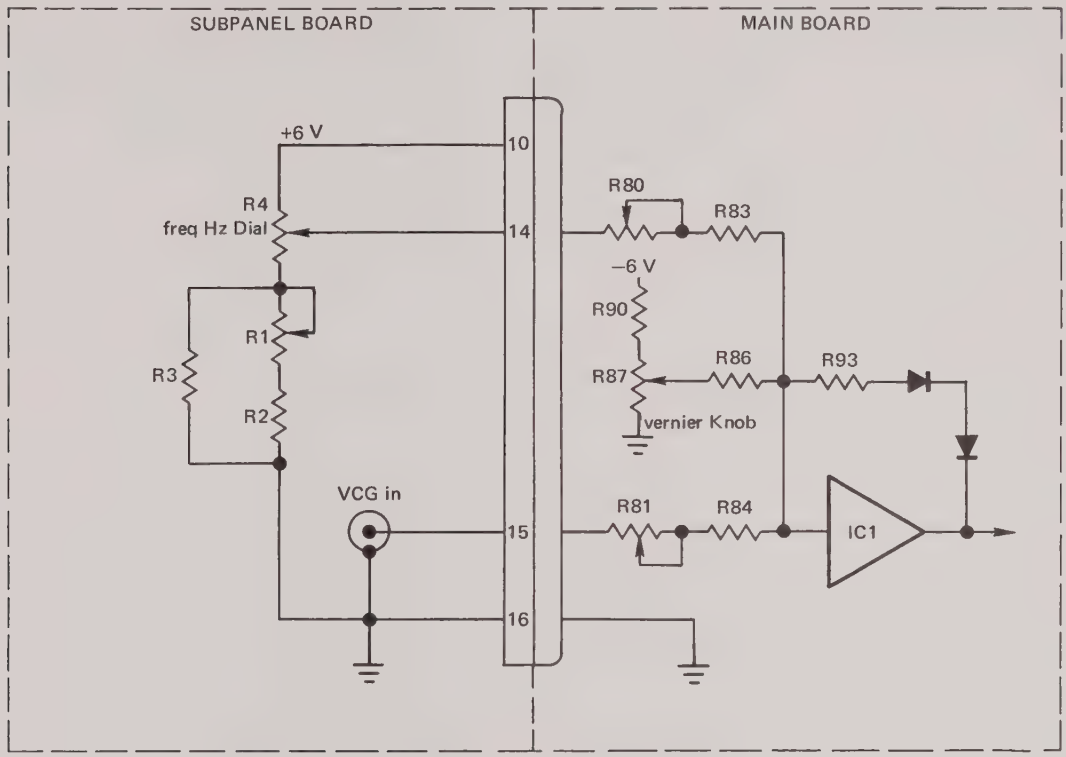


Figure 3-5. Voltage control-vs-frequency, simplified diagram.

position. Setting the *vernier* knob to its maximum counterclockwise position provides a frequency range to 0.05 Hz or vernier frequency adjustment at any setting of the *freq Hz* dial.

The noninverting input of IC1 (pin 4) maintains the amplifier summing node at absolute zero by adjustment of R89. The amplifier output (pin 12) is connected through pnp transistor Q30, two cascaded diodes in IC2, and integrating resistor R109 to the summing node of the integrator. Also, the output of IC1 is coupled through Q30 and two cascaded diodes in IC2 to the inverting input (pin 3) of VCG amplifier IC3.

The output of IC3 is connected to integrating resistor R110 which has one-half the ohmic value of R109. The output current of IC3 is coupled to the summing node of the integrator only when the square wave at Rin 7 is positive. Because of the comparative ohmic values of R109 and R110 and the bipolar voltage outputs of IC1 and IC3, equal and opposite currents are gated into the integrator summing node.

Integration Circuit

Because of the wideband frequency range of the Model 141, two integrating operational amplifiers are used. Transistor stages Q1 through Q10 form the integrator for the 0.05 Hz through 500 kHz range (Fig. 3-6). Stages Q11 through Q18 form the integrator for the 500 kHz through 5 MHz range (Fig. 3-7), which is essentially the same as the slow integrator.

Transistors Q1/Q3 and Q2/Q4 are connected as a dual-Darlington differential amplifier with the signal input applied to the Q1 base, and the reference voltage connected to the Q2 base. The dual-Darlington differential amplifier drives alternate bases of differential amplifier Q5/Q6 which, in turn, drive alternate bases of differential amplifier Q7/Q8. The output of this differential amplifier is single-ended and is used to drive the push-pull complementary emitter follower Q9/Q10.

NOTES

1. Located on Sine Converter Board.
2. Switch contacts 1 thru 5 are common.

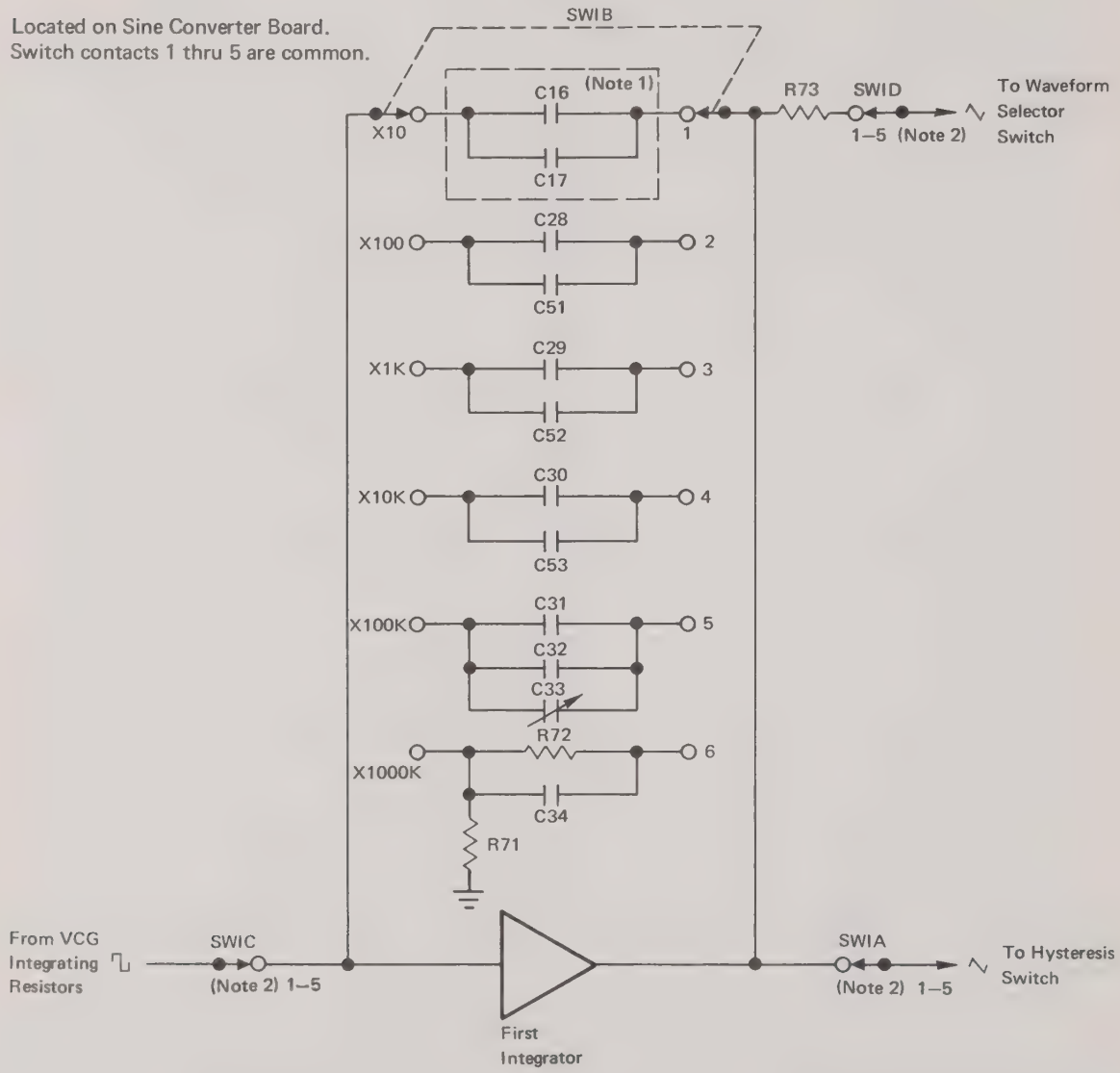


Figure 3-6. Low-frequency integration circuit, simplified diagram.

Diodes CR1 and CR2 prevent cross-over distortion. The emitter-follower triangle output is fed back to the first integrator summing node through the selected capacitive network of *freq Hz* range switch section SW1B, and to the hysteresis switch through switch section SW1A. The network in position 6 of SW1B provides the proper feedback path when the first integrator is disconnected from the closed loop. The triangle waveform is also connected through the SW1D section to wiper SW2C of the *function* selector.

The integrator for the 500 kHz to 5 MHz frequency range consists of the Q11 through Q18 stages (Fig. 3-7). The Q11/Q12 and Q14/Q13 stages are connected as a dual-Darlington differential amplifier. The signal input is connected to the Q11 base, and the reference voltage is connected to the Q14 base by the setting of potentiometer R27. The differential amplifier drives

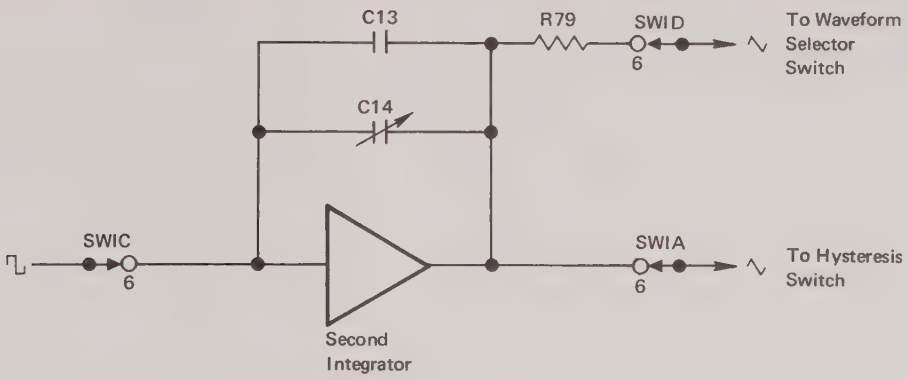


Figure 3-7. High-frequency integration circuit, simplified diagram.

alternate bases of a conventional differential amplifier (Q15/Q16). The single-ended output of this differential amplifier is applied to the bases of a complementary push-pull emitter follower. Diodes CR3 and CR4 prevent cross-over distortion. The emitter-follower triangle output is fed back to the integrator summing node through the proper capacitive network of SW1B when the *freq Hz* range selector switch is in the X 1M (position 6). The output is also applied through switch section SW1A to the hysteresis switch and through SW1D to the SW2C wiper of the *function* selector.

Hysteresis/Output Switch

The output of the selected integrator is applied to a complementary bipolar Schmitt trigger consisting of transistor stages Q19 through Q24. The Q19-Q21 stages are configured to operate on the positive ramp of the triangle waveform, and the Q22/Q24 stages on the negative ramp. The resistive inputs of the two bipolar sections set the threshold bias of the Q20 and Q22 bases so that these transistors turn on at +1.25 volts and −1.25 volts, respectively. The paralleled RC networks (R36/C15 and R39/C16) provide high-frequency compensation. Diodes CR5 and CR6 short the turn-off half-cycles of the triangle waveform to ground to shorten the respective turn-on times. Grounded-base amplifiers Q21 and Q24 provide temperature-compensated reference voltage for the emitters of Q20 and Q22, respectively. The regenerative feedback path is through the complementary-connected Q19 for the positive half-cycle and Q23 for the negative half-cycle. These stages also direct-couple their outputs to the bases of their corresponding stages in the output switch. A sinusoidal synchronizing input can be injected through isolating resistors R47 and R48.

The output switch is a bistable saturated switch. When the positive peak of the triangle waveform turns on section Q19/Q20 of the Schmitt trigger, Q25 turns on regeneratively through Q26, producing a +5-volt square wave half-cycle at emitter Q26. The same negative-going pulse that turns on Q25 is coupled through capacitor C19, turning off section Q27/Q28 of the bistable switch. When Q25 turns on, the positive potential at its collector is coupled through C23 and R56 to the Q20 emitter to reset this section of the Schmitt trigger. The output switch remains in this state until the negative peak of the triangle waveform turns on section Q22/Q23 of the Schmitt trigger. Section Q27/Q28 then turns on regeneratively, and Section Q25/Q26 turns off. The output from emitter Q27, in this case, is a −5 volt square wave half-cycle. Resistor R64 provides the initial turn-on bias for the output switch causing the switch to assume one bistable state or the other with power turn on.

The 10-volt peak-to-peak square wave output is coupled to three input circuits. The signal reduced to 1.3-volts peak-to-peak amplitude by the voltage divider composed of R69 and R70 for application to the VCG diode bridge at pin 6 of IC2. The signal is connected through potentiometer R67 and resistor R66 to *function* selector switch section SW2A. The signal is coupled through emitter follower Q29 and differentiated by the C2/R6 RC network on the Subpanel Board before being applied to the *sync out* connector.

Sine Conversion

When the *function* selector is in the ∿ position, the 2-volt peak-to-peak triangle waveform is connected through switch section SW2C on the Main Board to the

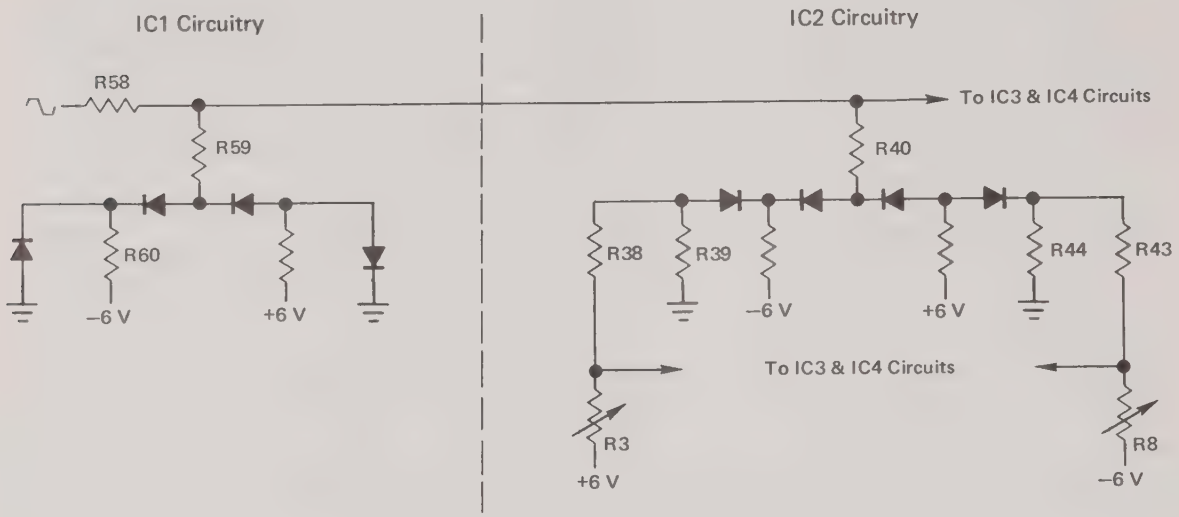


Figure 3-8. Sine conversion, simplified diagram.

input of the IC5 clipping circuit (pin 2) on the Sine Converter Board. The integrated circuit transforms the triangle wave into a waveform having a trapezoidal shape and 1.7-volts peak-to-peak amplitude. Resistors R50 and R56 provide the bipolar drive current for the integrated circuit bridge. The clipping action for the positive excursion is provided by potentiometer R46 and its associated diode. For the negative excursion, clipping is accomplished by the R54/diode combination.

Conversion of the trapezoidal wave into the sine wave is accomplished by four temperature-compensated diode-resistor networks that are biased to operate at the knee of the diode curve. The breakpoint-vs-divider relation is shown below. Figure 3–8 shows the first two breakpoint networks in a simplified schematic. The remaining two networks (which are seen in the Sine Converter schematic diagram) are configured the same as the IC circuitry, with only the resistor values being different.

Break-point	Divider	Break-point	Divider	Circuit
$+V_1$	None	$-V_1$	None	IC1
$+V_2$	R38/R39	$-V_2$	R43/R44	IC2
$+V_3$	R31/R32	$-V_3$	R35/R36	IC3
$+V_4$	R1/R2	$-V_4$	R6/R7	IC4

Due to the losses inherent in sine-shaping, diode-resistor networks, the amplitude of the shaped sine wave requires amplification before application to the output amplifier. Stages Q1 through Q6 form a potentiometric amplifier that provides the required 2-volts peak-to-peak output. Transistors Q1 and Q2 are connected as a differential amplifier with the signal applied to the Q1 base and the reference voltage taken from the output and applied to the Q2 base. Potentiometer R16 adjusts the dc balance, and R20 sets the amplifier gain. The balanced outputs from this amplifier are applied to alternate bases of differential amplifier Q3/Q4. The single-ended output of this amplifier is connected to a complementary-connected push-pull emitter follower. Diodes CR1 and CR2 prevent cross-over distortion. The sine-wave output is connected from the Sine Converter Board to the Main Board where it is applied to section SW2B of the *function* selector switch.

Power Amplification

The selected waveform is connected from the Main Board to the Power Amplifier Board. Amplification of this signal to the precise 10-volt peak-to-peak output signal into 50 ohms (approximately 20-volts peak-to-peak into open circuit), at 0-db attenuation, is

provided by a potentiometric amplifier consisting of stages Q1 through Q6. Attenuation of this amplitude over a 40-db range is accomplished in 10-db decrements by the resistive networks connected to switch sections SW1A through SW1D of the *volts p-p into 50 Ω* selector. A continuously-variable additional 10-db of attenuation is provided by the voltage divider consisting of R32 and R33. Adjustment of *vernier* potentiometer R32 sets the level of the input signal to the potentiometric amplifier at the base of Q2. The reference voltage is applied through potentiometer R28 to the base of Q1. The balanced output of this stage feeds the alternate bases of the following differential amplifier (matched-pair Q3/Q4). The output of this amplifier is single-ended and applied to complementary-connected push-pull emitter follower Q5/Q6. The push-pull output of the emitter follower is connected to the wiper of SW1B and taken from the wiper of SW1A. When in the 0-db and 10-db positions of the *volts p-p into 50 Ω* selector, the wiper of SW1B is connected directly to the wiper of SW1A. In the 20-db switch position, the resistive network, composed of R11, R13, R2 and R3, add 10-db of attenuation to the attenuation set in at the input to the potentiometric amplifier. In the 30-db position, R9, R10, R12, R14, and R1, add 20-db of attenuation to the input setting. In the 40-db position, R15, R8, and R4 through R7, add 30-db of attenuation. The selected amplitude level is connected from the Power Amplifier Board to the *50 Ω output* connector on the Subpanel Board.

Power Supply Voltages

The ac line cord connects the 115-volts ac power through ¾-ampere fuse F1, on the chassis Assembly to the *power* switch on the Subpanel Board. When this switch is in the *on* position, the 115-volts ac is connected across the paralleled primary windings of transformer T1 (on Chassis Assembly). This transformer has two center-tapped secondary windings that are connected to the two full-wave bridge rectifiers on the Mother Board. The bridge consisting of diodes CR1 through CR4 produce a positive and negative 15-volt dc, referenced to common return. The CR5 through CR8 bridge provides positive and negative 30-volts dc. Capacitors C1 through C4 are filter capacitors for their respective voltages; capacitors C5 and C6 provide decoupling for the Power Amplifier Board.

The unregulated 15-volt dc and 30-volt dc power is applied to the Power Regulator Board that provides regulated 6, 12, and 27-volts dc, of both polarities, as the operating voltages for the Model 141 solid-state devices. The basic reference voltage for the power supply is the regulated +6-volts dc output appearing at test point 1, TP1. This voltage is provided by the operational amplifier consisting of stages IC3, Q10, Q12, and Q13. The input to the amplifier is obtained through transistor Q9 which is connected to function as a Zener diode providing +6.7 volts at its collector. The voltage-divider, consisting of resistors R24, R28 and potentiometer R25, provides the means of adjusting the +6.7 volts to the proper input level for the IC amplifier. The inverted output is reinverted by common-emitter stage Q10 and given the proper gain by the Darlington stage, Q12/Q13. Resistor R29 is the feedback resistor. The regulated +6-volts dc is distributed from pin 13 of the Power Regulator Board to the Sine Board, Main Board, and Power Amplifier Board. Internally, the +6-volts dc is applied to the noninverting input of the operational amplifier consisting of stages IC4, Q11, Q14, and Q15. The positive output of the IC amplifier is inverted by common-emitter stage Q11 and applied to Darlington stage Q14/Q15. Resistor R32 is the feedback resistor for this operational amplifier. The regulated −6-volts dc is distributed from pin 14 of the Power Regulator Board to the Sine Board, Main Board, Power Amplifier Board, and to the index-marker lamp on the Subpanel Board.

The regulated +6-volts dc is also applied to the inverting input of the potentiometric amplifier, consisting of stages IC1, Q1, Q3, Q5, and Q7. The output of the IC amplifier is inverted by common-emitter stage Q1 and applied to biasing circuit Q5. The biasing circuit controls series-regulator Q7 to effect the +12 voltage regulation. If the +12-volts dc output attempts to rise, due to an increase in the unregulated voltage or the load current, the feedback to the noninverting input, pin 3 of IC1 causes a greater base current drive for Q1 and this, in turn, increases the Q1 collector current. The increase in Q1 I_C decreases the forward bias at the base of Q5, and the I_C of this stage decreases. The decreased I_C of Q5 reduces the base drive current to the series regulator and, therefore, effectively increases the collector-emitter impedance so that the increased voltage drop across Q7 returns the emitter output to +12-volts dc. A decrease in the regulated +12-volts dc output level has the opposite effect on this circuit. Stage Q3 is the turn-on circuit for the series regulator.

The −12-volt dc, +27-volt dc, and −27-volt dc circuits are functionally the same as the +12-volt dc regulator. The 27-volt regulators, however, have a separate Zener transistor (Q21), and the 27-volt distribution is to the Power Amplifier Board only.

SECTION 4
MAINTENANCE

INTRODUCTION

This section provides instructions for testing, adjusting, and troubleshooting the Model 141. These instructions are concise and for the experienced electronics technician or field engineer. WAVETEK maintains a factory repair department for those customers not possessing the necessary personnel or test equipment to maintain the instrument. If the instrument is returned to the factory for repair, a detailed description of the specific problem should be attached to facilitate the turn-around time.

RECOMMENDED TEST EQUIPMENT

Table 4-1 contains a list of recommended test equipment and extension cables. Any test equipment having equivalent accuracies may be substituted for those listed.

CHECKOUT AND CALIBRATION

The following subparagraphs provide complete sequential calibration procedures for the Model 141. Instrument checkout procedures are indicated by a checkmark (✓) following the procedure title. A quick checkout of the instrument can be performed by observing these indicated parameters and applying the tolerance factors given in the **Electrical Specifications** of Section One. Note: The entire calibration procedures must be read first to determine initial control settings and test equipment connections before attempting checkout or specific adjustments. Circuit board test-point and adjustment locations are shown on the board-layout diagrams in Section Five.

Preliminary Procedures ✓

1. Turn the *power* switch to *on.*
2. Allow ½ hour for warmup.
3. Center all internal controls, **unless checkout or a specific adjustment is being made**.
4. Set the *function* selector to ∿ .
5. Set the *freq Hz* selector to X10K.
6. Set the *freqHz* dial to its maximum clockwise stop.

Table 4-1. TEST EQUIPMENT AND SPECIAL CABLES

Name	Manufacturer	Model
Oscilloscope	Tektronix	543B
Plug-in unit	Tektronix	W
Electronic Counter	Computer Measurements	727D
Distortion Analyzer	Hewlett-Packard	332A
Spectrum Analyzer Display	Hewlett-Packard	141S
IF Amplifier	Hewlett-Packard	8552A
RF Amplifier	Hewlett-Packard	8553L
Dialamatic Voltmeter	Wavetek	201
Extension Cable, 6-conductor*	Wavetek	141-120
18-conductor*	Wavetek	141-119

*Not normally required, except for a few cases during troubleshooting.

7. Set the *vernier* knob to *cal*.
8. Set the *volts p-p into 50 Ω* selector to *0db*.
9. Set the *vernier* knob to *cal*.

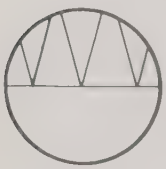
Power Supply Regulation

1. Connect the voltmeter between test point TP1 (+) and the 15-volt return on the Power Regulator Board. Adjust R25 for +6-volts dc ±50 mV.
2. Connect the voltmeter to TP2 (–), and check for –6-volts dc ±60 mV.
3. Connect the voltmeter to TP3 (+), and check for +12-volts dc ±120 mV.
4. Connect the voltmeter to TP4 (–), and check for –12-volts dc ±120 mV.
5. Connect the voltmeter between TP5 (+) and the 30-volt return. Check for +27-volts dc ±2 volts.
6. Connect the voltmeter to TP6 (–), and check for –27-volts dc ±2 volts.

Note: Ripple voltage for all preceding measurements should not exceed 5 millivolts.

∿ Amplitude

1. Set the oscilloscope controls to measure 1-volt peak as follows:
   a. Trigger Mode at auto.
   b. Trigger slope at int +.
   c. Single Sweep at Normal
   d. V_C range at +1.1 for positive peak; –1.1 for negative peak.
   e. Comparator volts at 1000.
   f. Input attenuator at 1.
2. Connect oscilloscope X1 probe at TP1 of Sine Board (ground clip) on ground bus.
3. Adjust R41 on the Main Board for +1.00-volt peak, then R42 for –1.00-volt peak as shown in the following sketch.



Negative Peak

Positive Peak

Frequency Dial Alignment

1. Reset the oscilloscope controls to measure +5.75-volts dc as follows:
   a. V_C +11.
   b. Comparator volt at 5750.
2. Connect the X1 probe to the center lug of the *freq Hz* dial potentiometer (R4 on Subpanel Board).
3. Turn the *freq Hz* dial until zero deflection is indicated on the oscilloscope. Loosen the dial set screw and mechanically align the *5* on the dial with the index marker above the dial.
4. Tighten the set screw and check that the oscilloscope is still at zero deflection.

Integrator Summing Null

1. Reset the oscilloscope V_C at 0.
2. Reset the *freq Hz* dial to align *.5* on dial with index marker.
3. Connect X1 probe to TP1 on Main Board, and adjust R9 for zero deflection.

Voltage-Controlled Generator Null

1. Reset the oscilloscope for conventional frequency display.
2. Reset the Model 141 controls as follows:
   a. Rotate the *freq Hz vernier* knob to its maximum counterclockwise stop.
   b. Set the *function* selector to ⎍ .
3. Connect the X1 probe to pin 3 of IC1 on the Main Board.
4. Adjust R89 for 0 volts at pin 3.

Periodic Symmetry and Timing √

When the square wave is positive, the output of the second VCG amplifier is connected to the integrator,

1. Reset the *freq Hz* dial to align the *5* with the index marker (*vernier* knob at *cal*). Adjust R103 (on Main Board) for top-of-dial time symmetry.
2. Connect the vertical output of the oscilloscope to the electronic counter as shown in Figure 4-1. Adjust R80 for 50 kHz.
3. Reset the *freq Hz* dial to align *.05* with the index marker and *vernier* knob to its counterclockwise stop. Adjust R94 (on Main Board) for bottom-of-dial time symmetry at 0.001 of dial setting.
4. Reset *vernier* to *cal* and adjust R9 for time symmetry at 0.01 of dial setting.
5. Repeat steps 1 and 2 until both 0.001 and 0.01 are symmetrical.
6. Reset *freq Hz* dial to *.5* and *vernier* knob to *cal.* Adjust R82 for 5 kHz on the counter display.
7. Reset the *freq Hz* dial to *.05*. Adjust R1 (on Subpanel Bd.) for 500 Hz on the counter display.

8. Recheck steps 3 and 4. Repeat adjustments, if necessary.

Note: Repeat all procedures from **Frequency Dial Alignment** through **Periodic Symmetry and Timing** until both top and bottom dial frequency and symmetry are within specifications.

VCG Linearity √

1. Set *freq Hz* at *.5* and *vernier* knob at *cal*.
2. Connect a low-impedance dc voltage source to the *VCG in* connector.
3. Set the dc voltage for +2.25 volts in *VCG in* connector. Adjust R81 (on Main Board) for 50 kHz on the counter display.
4. Observe counter display with the following dc voltage settings.

DC Input	Frequency	DC Input	Frequency
+2.25	50 kHz	+2.000	25 kHz
+2.0	45 kHz	+1.500	20 kHz
+1.75	40 kHz	+1.000	15 kHz
+1.5	35 kHz	+0.500	10 kHz
+1.25	30 kHz	0.000	5 kHz

Note: If necessary, readjust R81 slightly until linearity is within spec over the entire frequency range.

Power Amplifier Gain and Balance √

1. Reset the *function* selector to ∿ .
2. Adjust R36 (on Power Amplifier Board) for dc balance and R29 for 10-volts peak-to-peak.

⊓ Amplitude and Balance √

1. Reset *function* selector to ⊓ .
2. Adjust R65 (on Main Board) for dc balance and R67 for 10-volts peak-to-peak.

Fast MHz Integrator Balance and Ringing √

1. Reset *function* selector to ∿ and *freq Hz* range selector to *X1M.*
2. Adjust R29 (on Main Board) for best time symmetry at *.5* on the dial.

Power Amplifier Overshoot and Ringing √

1. Reset the *function* selector to ⊓ and *freq Hz* dial to *5*.
2. Adjust C1 (on Power Amplifier Board) to eliminate overshoot and ringing.

5 MHz Timing √

1. Leave the *freq Hz* dial at *5* and the range selector at *X1M*.
2. Adjust C14 (on Main Board) for 5 MHz on the counter display.

∿ Distortion, Amplitude, and Balance √

1. Connect the Model 141 and oscilloscope to the distortion analyzer as shown in Figure 4-2.
2. Reset Model 141 controls as follows:
   a. *function* selector to ∿ .
   b. *freq Hz* range selector to *X1K*.

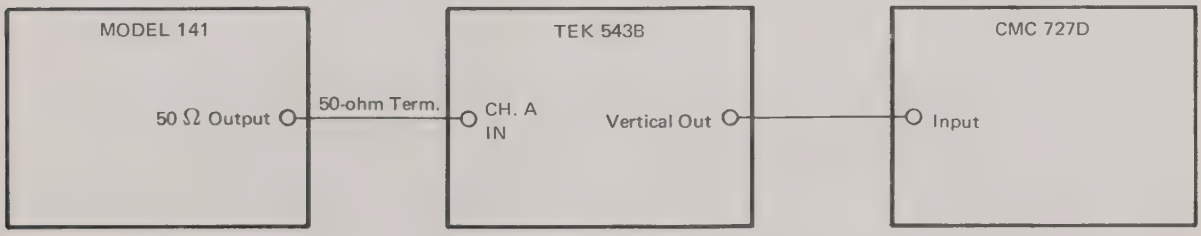


Figure 4-1. Frequency measurement test setup.

3. Reset the oscilloscope controls as follows:
   a. Horizontal deflection at 2 msec/cm.
   b. Trigger mode at dc.
   c. Trigger slope at Ext –.
   d. Horizontal display at Normal.
   e. Single sweep at Normal.
   f. V_C range at 0.
   g. Comparator volts at any setting.
   h. Vertical deflection at 50 mV/cm.
   i. Input attenuation at 1.
   j. Vertical display at A-V_C.
   k. Channel A at dc.
4. Set the distortion analyzer controls as follows:
   a. Frequency at 5 kHz.
   b. Set level at 1%.
5. Adjust the distortion analyzer for minimum curvature and amplitude on the oscilloscope display.
6. Adjust R3, R8, R46, and R54 (on Sine Converter Board) for minimum distortion.
7. Disconnect the distortion analyzer and reconnect the Model 141 *50 Ω output* to the Ch. A input connector of the oscilloscope, using the 50-ohm terminator on the X1 probe.
8. Adjust R16 (on Sine Converter Board) for dc balance and R20 for 10-volts peak-to-peak amplitude on the oscilloscope display.
9. Reconnect the distortion analyzer as shown in Figure 4-2. Reset the *freq Hz* dial to *.5*.
10. Check that sine-wave distortion does not exceed 0.5%.
11. Disconnect the distortion analyzer and oscilloscope and connect the spectrum analyzer to the Model 141 as shown in Figure 4-3.
12. With the *freq Hz vernier* knob at the *cal* position, set the *freq Hz* range selector to *X1M*. Swing the *freq Hz* dial from CCW stop to CW stop, while observing the spectrum display. The harmonic components should be at least 30-db down from the fundamental frequency.
13. Repeat step 12 for each of the other five *freq Hz* range selector settings.

Frequency √

1. Connect the Model 141, the oscilloscope, and the electronic counter as shown in Figure 4-1.
2. Set the Model 141 controls as follows:
   a. *freq Hz* dial at the *5* calibration.
   b. *freq Hz vernier* knob at *cal* position.
   c. *freq Hz* selector at *X100K* range.
3. Adjust C33 (on Main Board) for 500 kHz on the counter display.
4. Sequentially set *freq Hz* range selector to each of the following settings and check for the indicated frequencies.

Note: Selection of trim capacitors is a factory adjustment.

freq Hz Range Selector	Frequency
X10K	50 kHz
X1K	5 kHz
X100	500 Hz
X10	50 Hz

Sync Trigger Output √

1. Disconnect the counter and connect the oscilloscope X1 probe to the *sync out* counter on the front panel.

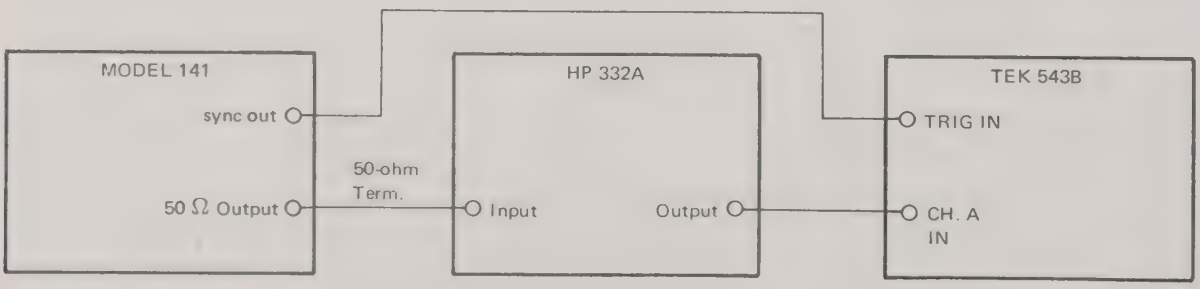


Figure 4-2. Distortion analysis test setup.

8. Recheck steps 3 and 4. Repeat adjustments, if necessary.

Note: Repeat all procedures from **Frequency Dial Alignment** through **Periodic Symmetry and Timing** until both top and bottom dial frequency and symmetry are within specifications.

VCG Linearity √

1. Set *freq Hz* at *.5* and *vernier* knob at *cal*.
2. Connect a low-impedance dc voltage source to the *VCG in* connector.
3. Set the dc voltage for +2.25 volts in *VCG in* connector. Adjust R81 (on Main Board) for 50 kHz on the counter display.
4. Observe counter display with the following dc voltage settings.

DC Input	Frequency	DC Input	Frequency
+2.25	50 kHz	+2.000	25 kHz
+2.0	45 kHz	+1.500	20 kHz
+1.75	40 kHz	+1.000	15 kHz
+1.5	35 kHz	+0.500	10 kHz
+1.25	30 kHz	0.000	5 kHz

Note: If necessary, readjust R81 slightly until linearity is within spec over the entire frequency range.

Power Amplifier Gain and Balance √

1. Reset the *function* selector to ∿ .
2. Adjust R36 (on Power Amplifier Board) for dc balance and R29 for 10-volts peak-to-peak.

⊓ Amplitude and Balance √

1. Reset *function* selector to ⊓ .
2. Adjust R65 (on Main Board) for dc balance and R67 for 10-volts peak-to-peak.

Fast MHz Integrator Balance and Ringing √

1. Reset *function* selector to ∿ and *freq Hz* range selector to *X1M*.
2. Adjust R29 (on Main Board) for best time symmetry at *.5* on the dial.

Power Amplifier Overshoot and Ringing √

1. Reset the *function* selector to ⊓ and *freq Hz* dial to *5*.
2. Adjust C1 (on Power Amplifier Board) to eliminate overshoot and ringing.

5 MHz Timing √

1. Leave the *freq Hz* dial at *5* and the range selector at *X1M*.
2. Adjust C14 (on Main Board) for 5 MHz on the counter display.

∿ Distortion, Amplitude, and Balance √

1. Connect the Model 141 and oscilloscope to the distortion analyzer as shown in Figure 4-2.
2. Reset Model 141 controls as follows:
   a. *function* selector to ∿ .
   b. *freq Hz* range selector to *X1K*.

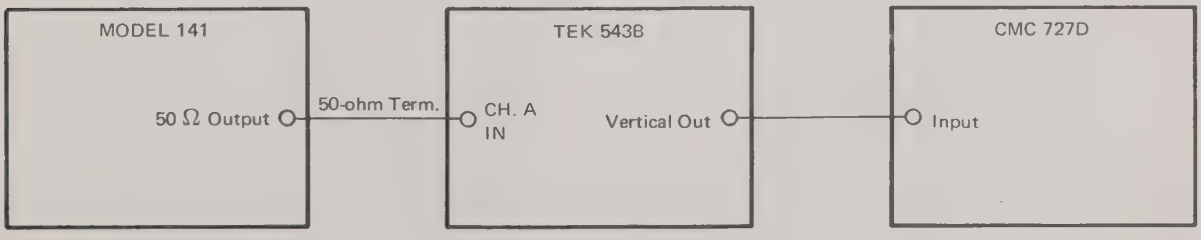


Figure 4-1. Frequency measurement test setup.

3. Reset the oscilloscope controls as follows:
   a. Horizontal deflection at 2 msec/cm.
   b. Trigger mode at dc.
   c. Trigger slope at Ext –.
   d. Horizontal display at Normal.
   e. Single sweep at Normal.
   f. V_C range at 0.
   g. Comparator volts at any setting.
   h. Vertical deflection at 50 mV/cm.
   i. Input attenuation at 1.
   j. Vertical display at A-V_C.
   k. Channel A at dc.
4. Set the distortion analyzer controls as follows:
   a. Frequency at 5 kHz.
   b. Set level at 1%.
5. Adjust the distortion analyzer for minimum curvature and amplitude on the oscilloscope display.
6. Adjust R3, R8, R46, and R54 (on Sine Converter Board) for minimum distortion.
7. Disconnect the distortion analyzer and reconnect the Model 141 *50 Ω output* to the Ch. A input connector of the oscilloscope, using the 50-ohm terminator on the X1 probe.
8. Adjust R16 (on Sine Converter Board) for dc balance and R20 for 10-volts peak-to-peak amplitude on the oscilloscope display.
9. Reconnect the distortion analyzer as shown in Figure 4-2. Reset the *freq Hz* dial to *.5*.
10. Check that sine-wave distortion does not exceed 0.5%.
11. Disconnect the distortion analyzer and oscilloscope and connect the spectrum analyzer to the Model 141 as shown in Figure 4-3.
12. With the *freq Hz vernier* knob at the *cal* position, set the *freq Hz* range selector to *X1M*. Swing the *freq Hz* dial from CCW stop to CW stop, while observing the spectrum display. The harmonic components should be at least 30-db down from the fundamental frequency.
13. Repeat step 12 for each of the other five *freq Hz* range selector settings.

Frequency ✓

1. Connect the Model 141, the oscilloscope, and the electronic counter as shown in Figure 4-1.
2. Set the Model 141 controls as follows:
   a. *freq Hz* dial at the *5* calibration.
   b. *freq Hz vernier* knob at *cal* position.
   c. *freq Hz* selector at *X100K* range.
3. Adjust C33 (on Main Board) for 500 kHz on the counter display.
4. Sequentially set *freq Hz* range selector to each of the following settings and check for the indicated frequencies.

Note: Selection of trim capacitors is a factory adjustment.

freq Hz Range Selector	Frequency
X10K	50 kHz
X1K	5 kHz
X100	500 Hz
X10	50 Hz

Sync Trigger Output ✓

1. Disconnect the counter and connect the oscilloscope X1 probe to the *sync out* counter on the front panel.

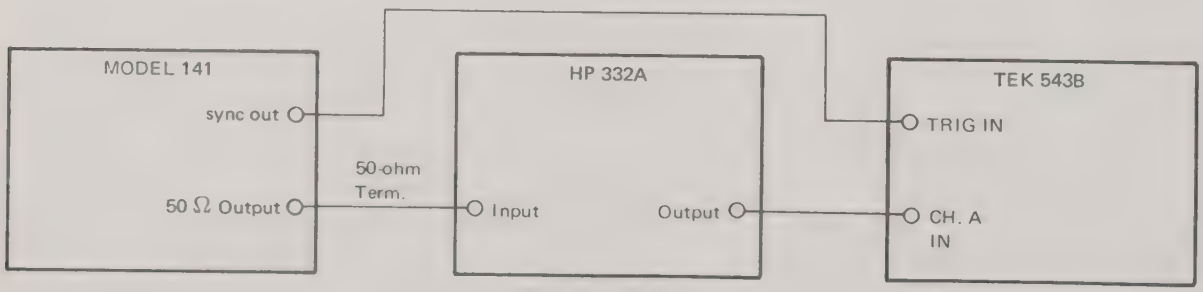


Figure 4-2. Distortion analysis test setup.

2. Check for at least 1-volt peak amplitude for all frequency ranges.

Synchronizing Input ✓

1. Connect the *50 Ω output* of the Model 141 to the CH. A input of the oscilloscope.
2. Connect a sine-wave source at 5 kHz and at 5-volts peak-to-peak to the *sync input* connector.
3. Set the Model 141 for a 5 kHz square wave.
4. Set the oscilloscope to display one cycle. Expand to X10 magnification and align the leading edge of the square wave with the center vertical of the oscilloscope graticule.
5. Increase the sine-wave frequency until the signal drops out of sync (jitter is seen). Return the sine-wave frequency to sync; then decrease the frequency until loss of sync occurs again. Loss of sync should not occur at less than 1% of generator frequency (±50 Hz at 5 kHz).

Output Amplitude Attenuation ✓

1. Check the output attenuation with the oscilloscope by setting the *volts p-p into 50 Ω* selector (*vernier* at *cal* position) as follows:

Setting	(volts p-p)
0db	10.000
−10db	3.160
−20db	1.000
−30db	0.316
−40db	0.100

2. Set *volts p-p into 50Ω* selector at *0db*.
3. Rotate *vernier* knob to its maximum counter-clockwise position and check for amplitude less than 3.16 Vp-p (greater than −10 db).

TROUBLESHOOTING

Basic Techniques

Troubleshooting the Model 141 requires no special techniques. Listed below are a few reminders of basic electronics fault isolation.

1. Check control settings carefully: many times an incorrect control setting, or a knob that has loosened on its shaft, will cause a false indication of a malfunction.
2. Check associated equipment connections: Make sure that all connections are properly connected to the correct connector.
3. Perform the checkout procedures: Many out-of-specification indications can be corrected by recalibrating the instrument.
4. Visually check the interior of the instrument: Look for such indications as broken wires, charred components, loose leads, etc.

Troubleshooting Chart

Table 4-2 provides a list of some symptoms of malfunctions, their probable causes, and the prescribed remedies. Also listed in this table are the locations of the suspect circuit, the test points at which measurements are to be made, and the numerical values of the parameters at these test points.

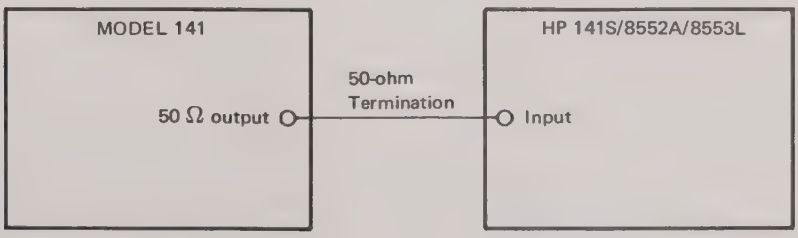


Figure 4-3. Spectrum analysis test setup.

Table 4-2. TROUBLESHOOTING CHART

Symptom	Probable Cause and Remedy	Location	Test Point	Parameter
No waveform output on any frequency range	Fault in generator loop. Set *freq Hz* dial at *5 vernier* at *cal, freq Hz* at *X1K.**	Subpanel Board Main Board	J3-14/16 IC3–12 TP1 TP2 TP6	+5.75 Vdc +5 Vdc 0 volts ∿ 2.5 volts p-p ⊓ 2 volts p-p
	Blown fuse	Chassis Assy	Fuse	¾ A, 3AG, slow-blow
No waveform output on *X1M* range	Fault in fast integrator circuit. Set *freq Hz* dial at *5, vernier* at *cal.*	Main Board	TP4 TP3	2.5 volts p-p 0 volts
No waveform output on *X10–X100K* range	Fault in normal integrator circuit. Set *freq Hz* dial at *5, vernier* at *cal.*	Main Board	TP2 TP1	2.5 volts p-p 0 volts
No sync output	Fault in sync trigger circuit. Set *freq Hz* control for 500 kHz and *function* for ⊓ .	Subpanel Board Main Board	*sync out* Q29-E	2 volts p-p ⊓ 2 volts p-p
All waveforms down in amplitude	Fault in Power Amplifier circuit.	Power Amplifier Board	TP4 TP3 TP1	10 volts p-p 10 volts p-p 2 volts p-p
	Fault in Power Regulator circuit	Power Regulator Board	TP1 TP2 TP3 TP4 TP5 TP6	+6 Vdc ±60 mV –6 Vdc ±60 mV +12 Vdc ±120 mV –12 Vdc ±120 mV +27 Vdc ±2 volts –27 Vdc ±2 volts
	Fault in Power Supply circuit	Mother Board	J3-8/9 J3-7/9 J3-6/1 J3-5/1	–15 Vdc +15 Vdc –30 Vdc +30 Vdc
No ∿ output	Fault in Sine Conversion circuit.	Sine Converter Board	TP2 TP4 TP3 TP1	∿ 2 volts p-p ∿ 0.42 volts p-p ∿ 1.6 volts p-p ∿ 2 volts p-p
∿ output not in spec	Maladjustment or change in semiconductor characteristics. Perform ∿ Distortion, Amplitude, and Balance adjustment.	Sine Converter Board	*50 Ω output*	See **Electrical Specifications**
⊓ output not in spec	Maladjustment or change in semiconductor characteristics. Perform ⊓ Amplitude, and Balance adjustment.	Main Board	*50 Ω output*	See **Electrical Specifications**

*Refer to **Troubleshooting Hints** if parameters are not in spec.

To use the troubleshooting chart, locate the symptom listed in column one and follow the procedures. Localize the fault to a specific stage by checking the parameters given for the major test points; then check the dc operating voltages at transistor collectors and/or emitters or integrated-circuit dc voltage pins. Check associated passive elements with an ohmmeter (power off) before replacing a suspected semiconductor element.

Troubleshooting Hints

To check the generator loop, proceed as follows:

1. Set the Model 141 controls for a 10 Vp-p, 5 kHz sine-wave output.
2. Unsolder and lift the leadwire from test point, TP2 on the Main Board.
3. Inject a sine or triangle waveform of approximately 5 kHz and between 3 Vp-p and 5 Vp-p into the lifted leadwire.
4. Check at test point 5 for a square-wave output. If there is no output, the fault is in the hysteresis switch/output switch stages. If an output is observed, proceed to step 5.
5. Inject a sine or triangle waveform of approximately 5 kHz and 5 Vp-p through a 2-kilohm resistor into TP1.
6. Check at TP2 for a triangle-wave output. If there is no output, the fault is in the slow integrator. If an output is observed, proceed to step 7.
7. First check at the emitter of Q30 for 0 to –5Vdc; then check at the junction of R110/IC3–12/IC2–12 for 0 to +5 Vdc as the *freq Hz* dial is rotated from its clockwise stop to its counter-clockwise stop in each case.
   a. If the proper output is obtained in each case, the fault is in the diode gating circuit.
   b. If no output is obtained in either case, the fault is in R1 through R4 network on the Subpanel Board.
   c. If an output is obtained from only one VCG amplifier, the nonoperating VCG amplifier stage is at fault.

REPLACEMENT OF CIRCUIT BOARDS

Refer to the Chassis Assembly illustration in Section Five as a visual aid to the following procedural instructions.

Replacement of Main Board

1. Remove the four screws on the right left sides of the cover and pull off the cover.
2. Loosen set screws and remove *function* knob, *vernier* knob, and *freq Hz* range knob.
3. Remove screws holding board guide to rear of chassis and slide out guide.
4. Lift the board out of its rear connector; angle outward and remove the board from the front connector.
5. Installation of the Main Board is essentially the reverse of removal.

Replacement of Sine Board

1. Remove the Main Board.
2. Remove screws holding board guide to rear of chassis and slide out guide.
3. Lift the board out of its rear connector; angle outward and remove the board from its front connector.
4. Installation of the Sine Board is essentially the reverse of removal.

Replacement of Power Regulator Board

1. With cover off, remove the No. 6 machine screw, hex nut and lockwasher retaining the front of the board to the heat shield.
2. Remove the No. 6 panhead screw and lockwasher that retains the board to the rear panel.
3. Pull the board striaght up out of its connector.
4. Installation of the Power Regulator Board is essentially the reverse of removal.

Removal of Heat Shield

1. Remove the Power Regulator Board.
2. Loosen the set screw holding the *freq Hz* dial on its shaft and pull off the dial.
3. Remove the two No. 6 flat-head machine screws that retain the front of the heat shield to the chassis.
4. Remove the three pan-head screws that retain the rear of the heat shield and Sine Board guide to the chassis and lift out the heat shield.
5. Installation of the heat shield is essentially the reverse of removal.

Note: Whenever the *freq Hz* dial is reinstalled, the **Frequency Dial Alignment** in Section Four must be performed.

Replacement of the Output Amplifier Board

1. Loosen set screws holding *volts p-p into 50Ω* knobs to shaft and remove these knobs.
2. With cover off, remove screws holding board guide to rear of chassis and slide out guide.
3. Lift the board out of its rear connector; angle outward and remove the board from its front connector.

4. Installation of the Output Amplifier Board is essentially the reverse of removal.

Replacement of Mother Board

1. Perform all of the preceding board removal procedures.
2. Remove the six No. 6 flat-head machine screws, hex nuts, and lockwashers that retain the board to the bottom of the chassis.
3. Slide the board forward to gain access to the Amphenol pin connectors and disconnect the power cable leads.
4. Remove the cable from the board by pulling straight up at the fastener end of the cable clamp.
5. Installation of the Mother Board is essentially the reverse of removal.

Note: The Main and Output Amplifier Boards must be installed to align the Mother Board connectors.

Replacement of Subpanel Board

1. Perform all of the preceding removal procedures, except the Mother Board.
2. Remove dial lamp from socket.
3. Loosen the set screw and remove the *power* knob.
4. Remove the two phillips-head screws at the bottom of the front panel. Remove hex nuts and lock washers at the top of the left and right connectors on the Subpanel Board.
5. Pull back and lift out the board.
6. Installation of the Subpanel Board is essentially the reverse of removal.

NOTE:

1. After replacing any board, make sure that connector pin and socket alignment is correct.
2. After replacing any board, except Mother Board or Subpanel Board, perform the calibration procedures in Section Four for that board.
3. After performing the specific calibration procedures for the replaced board, go through the complete checkout procedure for the instrument.

SECTION 5
PARTS LIST

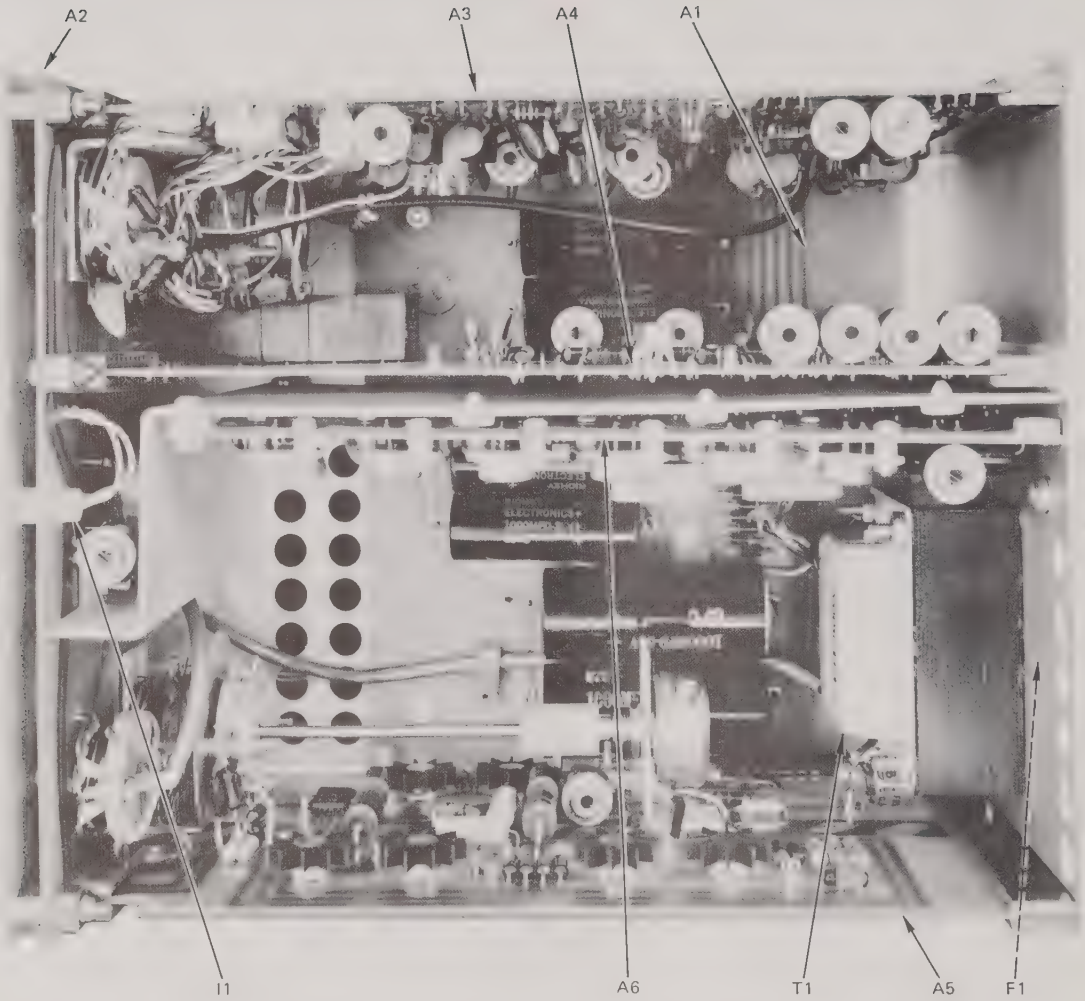
INTRODUCTION

This section contains a list of replaceable electrical parts for the Model 141 Function Generator. Bulk items, such as wire, insulation, etc., and hardware, are not included. All electrical replacement parts can be obtained from the listed manufacturer or WAVETEK. However, many of the standard electronic components can be purchased locally in less time than is required to order from the manufacturer. Make sure that the replacement part ratings agree with the values, requirement, tolerance, and description in the parts list. The size of the replacement part is not only critical as an installation requirement, but also may effect circuit performance at the higher frequencies. A list of recommended manufacturers is included in this section.

PARTS LIST ARRANGEMENT

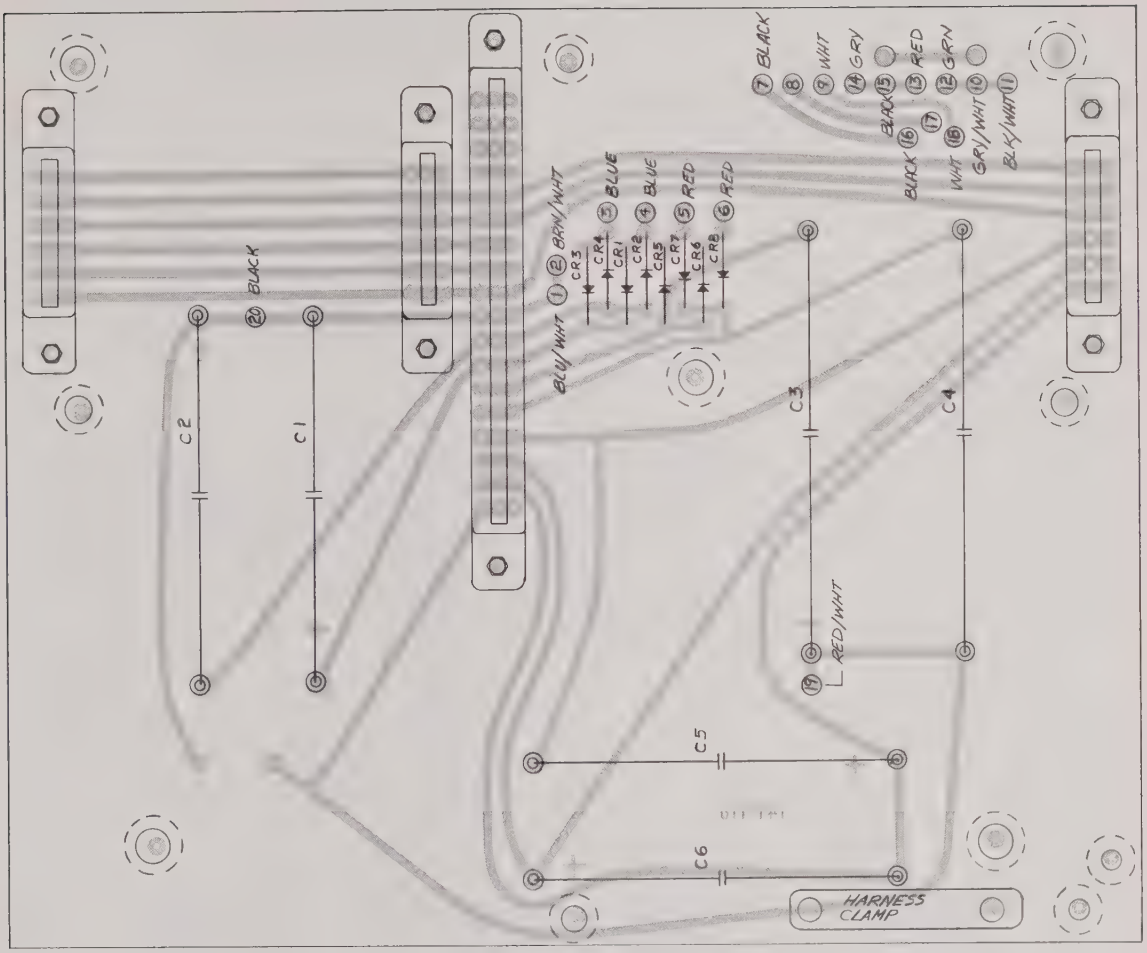
All parts lists in this section are arranged with an illustration showing the location of the parts followed by a listing of these parts. The drawing/list divisions are arranged in the following sequence:

Name	Assembly No.	Page
Chassis Assembly	141-000	5-2
Mother Board	141-018	5-3
Subpanel Board	141-016A	5-4
Main Board	141-012F	5-6
Sine Converter	141-017	5-9
Power Regulator	141-014C	5-11
Power Amplifier	141-015A	5-13



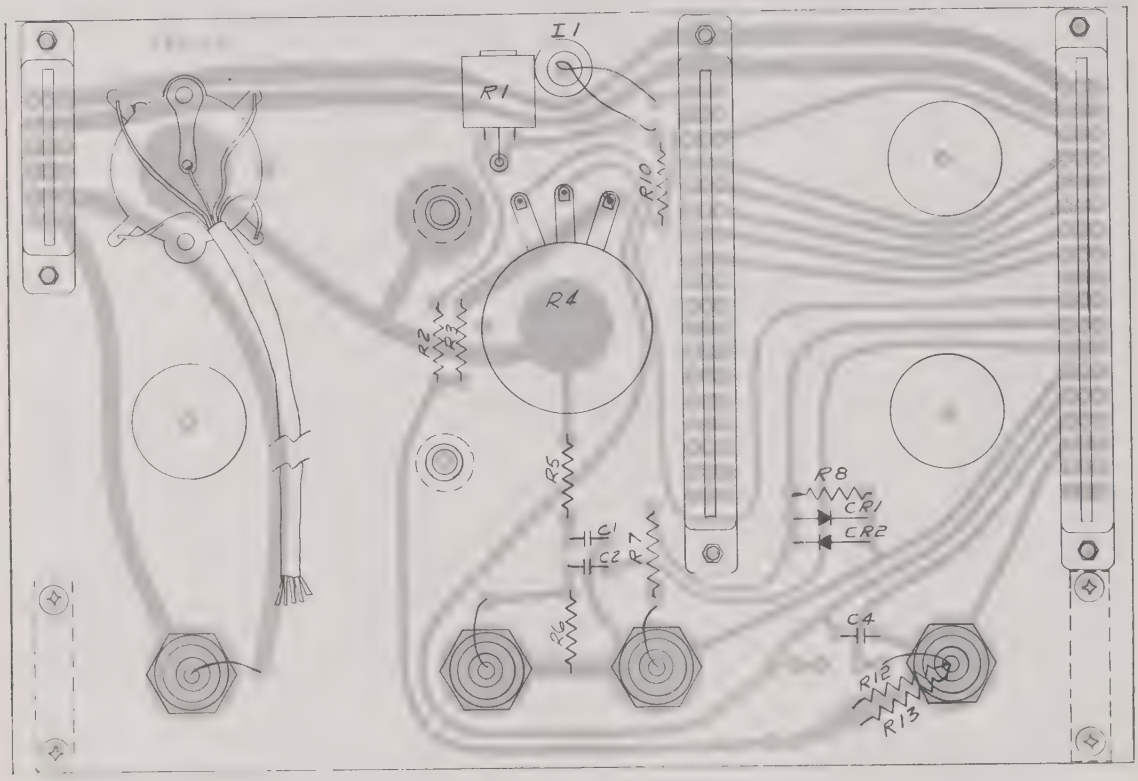
CHASSIS ASSEMBLY BOARD (No. 141-000)

REFERENCE	DESCRIPTION	NAME	Part NUMBER
A1	Mother Board	Wavetek	141-018
A2	Subpanel Board	Wavetek	141-016
A3	Main Board	Wavetek	141-012C
A4	Sine Converter Board	Wavetek	141-017
A5	Power Amplifier Board	Wavetek	141-015A
A6	Power Regulator Board	Wavetek	141-014C
F1	Fuse, ¾ amp, 250 V	Littelfuse	312.750
I1	On/Off Indicator with Scribe Line	Wavetek	141-317
T1	Transformer	Wavetek	141-500A



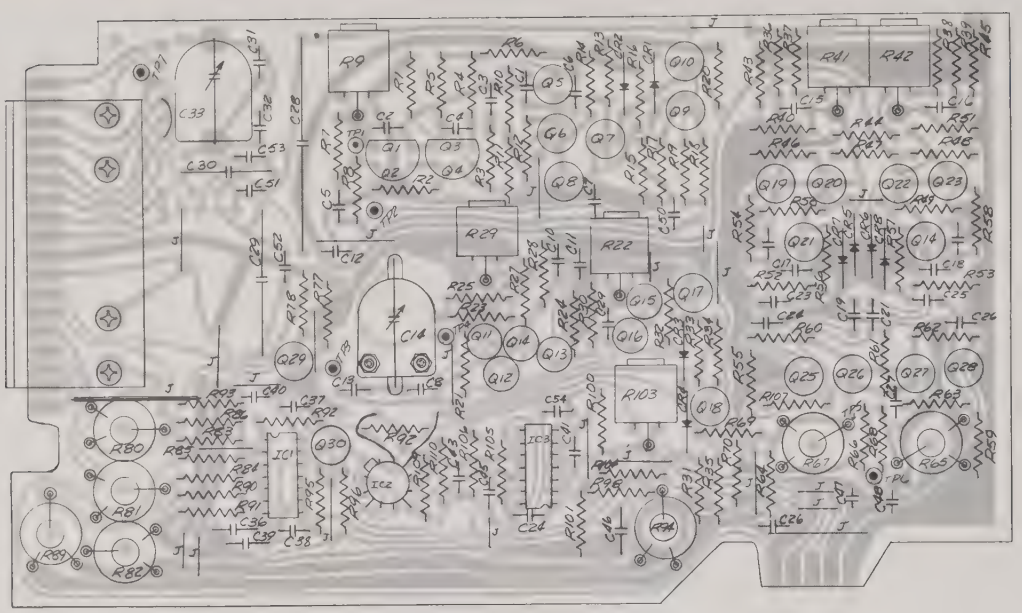
MOTHER BOARD (No. 141-018)

REFERENCE	DESCRIPTION	NAME	PART NUMBER
Capacitors			
C1,C2,C5,C6	35 V, 1000 μF	Richey	35-750-100-35T
C3,C4	50 V, 1000 μF	Richey	35-750-100-50T
Diodes			
CR1–8	Silicon	Sem	SCE-1


I1
R1
R10
R4
R2
R3
R5
C1
C2
R7
R8
CR1
CR2
C4
R12
R13

SUBPANEL BOARD (No. 141-016)

REFERENCE	DESCRIPTION	NAME	PART NUMBER
Capacitors			
C1	Ceramic, 1000 V, 330 pF	CRL	DD331
C2,C4	Ceramic, 50 V, 0.01 μF	CRL	CK103
Diodes			
CR1,CR2	Silicon	Fair	FD6666
Potentiometers			
R1	100 Ω	A/B	FR101M
R4	1 k	A/B	JA1N104P102UA
Resistors			
R2	Metal film, ¼ W, 1%, 21.5 Ω	Corn	RN60D
R3	Metal film, ¼ W, 1%, 12.4 Ω	Corn	RN60D
R5	Carb, ½ W, 5%, 27 Ω	Stack	RC20GF270J
R6	Carb, ½ W, 10%, 10 k	Stack	RC20GF103K
R7	Metal film, ¼ W, 1%, 576 Ω	Corn	RN60D
R8	Metal film, ¼ W, 1%, 124 Ω	Corn	RN60D
R10	Carb, ½ W, 5%, 39 Ω	Stack	RC20GF390J
R12,R13	Metal film, ¼ W, 1%, 100Ω	Corn	RN60D
Switch Assembly			
103-SW2	Wafer, switch	Wavetek	103-SW2

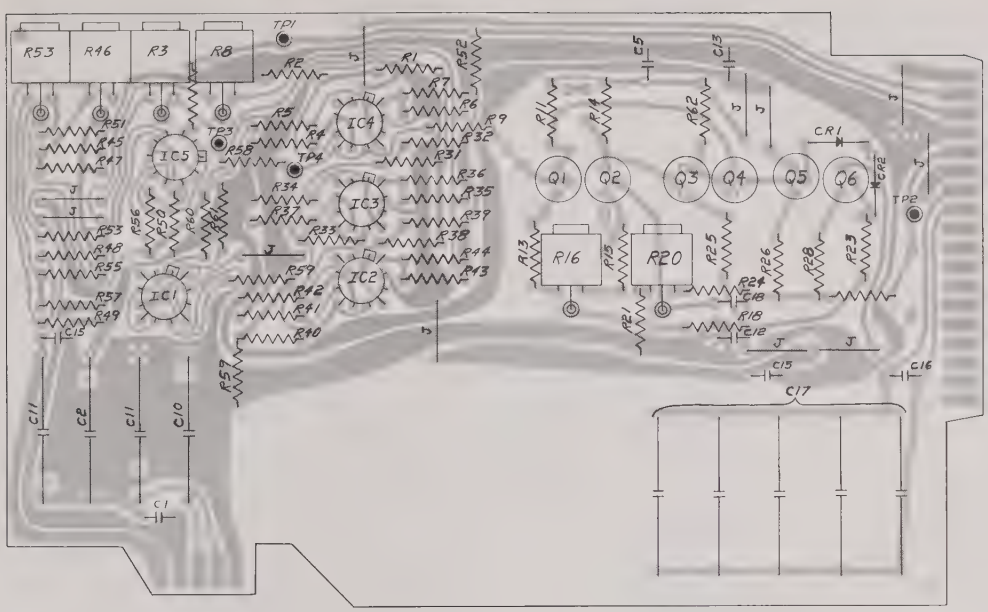


MAIN BOARD (No. 141-012F)

REFERENCE	DESCRIPTION	NAME	PART NUMBER
Capacitors			
C1,C2,C8,C34,C54	Ceramic, 100 pF	Arco	DM15-101
C3	Silver Mica, 750 pF	Arco	DM15-911J
C4,C5,C10	Ceramic, 1000 V, 0.001 μF	Arco	DD102
C6,C7,C11,C12,C17,C18, C24,C26	Ceramic, 10 V, 0.1 μF	Arco	UK10-104
C9	Ceramic, 220 pF	Arco	DD221
C13	Silver Mica, 5%, 68 pF	Arco	DM15-680
C14,C33	Variable, 4.5–25 pF	Erie	503-011-37A
C15,C16	Silver mica, 1%, 62 pF	Arco	DM15-620F
C19,C21	Ceramic, 47 pF	CRL	DD470
C20,C22,C37,C38,C42,C43	Ceramic, 22 pF	CRL	DD220
C23,C25	Ceramic, 680 pF	Arco	DD681
C27	Ceramic, 10 pF	CRL	DD100
C28	Polystyrene, 1%, 1 μF	IBM	210B1C105F
C29	Polystyrene, 100 V, 0.1 μF	Arco	PO104G1
C30	Polystyrene, 100 V, 0.01 μF	Arco	WMFIPIE
C31	Silver Mica, 910 pF	Arco	DM15-911
C35,C55	Ceramic, 1000 V, 0.0022 μF	Arco	DD222
C36,C39,C45,C46	Ceramic, 20 V, 0.1 μF	Arco	UK20-104
C40,C41	Ceramic, 5 pF	CRL	DD050
C47,C48	Ta, 15 V, 33 μF	Sprague	196D336X0015FB
C49	Ceramic, 680 pF	CRL	DM15-681J

REFERENCE	DESCRIPTION	NAME	PART NUMBER
Diodes			
CR1–9	Silicon	Fair	FD6666
Integrated Circuits			
IC1,IC3	Operational Amplifier	RCA	CA3030
IC2	Diode bridge	RCA	CA3019
Potentiometers			
R9,R29,R65,R82,R89,R94	100 k	A/B	FR104M
R22,R80,R81,R103	500 Ω	A/B	FR501M
R41,R42	250 Ω	A/B	FR251M
R67	100 Ω	A/B	FR101M
R87	10 k	Wavetek	112-SW7
Resistors			
R1,R2,R7,R85	Metal film, ¼ W, 1%, 110 k	Corn	RN60D
R3	Carb, ½ W, 5%, 75 Ω	Stack	RC20GF750J
R4,R5,R15,R31,R110	Metal film, ¼ W, 1%, 1 k	Corn	RN60D
R6	Metal film, ¼ W, 1%, 46.4 k	Corn	RN60D
R8,R28,R43,R44	Metal film, ¼ W, 1%, 2 k	Corn	RN60D
R10,R12	Metal film, ¼ W, 1%, 100 Ω	Corn	RN60D
R11,R46,R51,R68	Metal film, ¼ W, 1%, 3.01 k	Corn	RN60D
R13,R14,R99	Metal film, ¼ W, 1%, 3.83 k	Corn	RN60D
R16	Carb, ½ W, 5%, 130 Ω	Stack	RC20GF131J
R17,R20,R32,R35	Carb, ½ W, 5%, 51 Ω	Stack	RC20GF510J
R18,R19	Carb, ½ W, 5%, 4.7 Ω	Stack	RC20GF4R7J
R21,R24,R27	Metal film, ¼ W, 1%, 10 k	Corn	RN60D
R23,R25	Metal film, ¼ W, 1%, 49.9 Ω	Corn	RN60D
R26,R49,R50	Metal film, ¼ W, 1%, 4.75 k	Corn	RN60D
R30,	Carb, ½ W, 5%, 150 Ω	Stack	RC20GF151J
R33,R34	Carb, ½ W, 5%, 15 Ω	Stack	RC20GF150J
R36,R39,R66	Metal film, ¼ W, 1%, 316 Ω	Corn	RN60D
R37,R38	Metal film, ¼ W, 1%, 825 Ω	Corn	RN60D
R40,R45	Metal film, ¼ W, 1%, 3.92 k	Corn	RN60D
R47,R48	Metal film, ¼ W, 1%, 21.5 k	Corn	RN60D
R52,R53	Carb, ½ W,10%,470 Ω	Stack	RC20GF471K
R54,R58,R91	Metal film, ¼ W, 1%, 1.1 k	Corn	RN60D
R55,R59	Metal film, ¼ W, 1%, 249 Ω	Corn	RN60D
R56,R57	Carb, ½ W, 10%, 2.2 k	Stack	RC20GF222K
R60,R62	Metal film, ¼ W, 1%, 15 Ω	Corn	RN60D

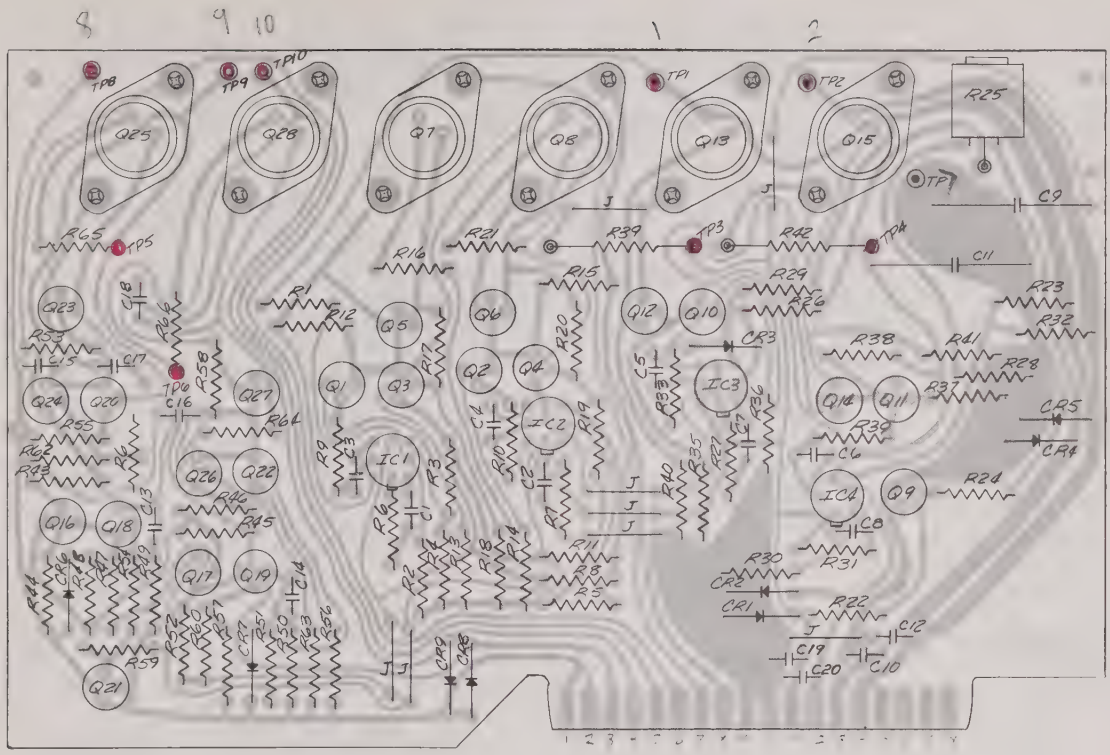
REFERENCE	DESCRIPTION	NAME	PART NUMBER
Resistors			
R61	Metal film, ¼ W, 1%, 61.9 Ω	Corn	RN60D
R63,R107	Carb, ½ W, 5%, 10 Ω	Stack	RC20GF100J
R64	Carb, ½ W, 5%, 3 k	Stack	RC20GF302J
R69	Metal film, ¼ W, 1%, 576 Ω	Corn	RN60D
R70	Metal film, ¼ W, 1%, 124 Ω	Corn	RN60D
R71,R72,R83,R93,R100	Metal film, ¼ W, 1%, 4.02 k	Corn	RN60D
R73,R79	Metal film, ¼ W, 1%, 21.5 Ω	Corn	RN60D
R74–76	Metal film, ¼ W, 1%, 90.9 Ω	Corn	RN60D
R77,R78	Carb, ½ W, 10%, 1 k	Stack	RC20GF102K
R84	Metal film, ¼ W, 1%, 1.78 k	Corn	RN60D
R86	Metal film, ¼ W, 1%, 402 k	Corn	RN60D
R90,R98	Metal film, ¼ W, 1%, 464 k	Corn	RN60D
R92,R95,R96,R105,R106	Carb, ½ W, 5%, 2 k	Stack	RC20GF202J
R104	Metal film, ¼ W, 1%, 2.37 k	Corn	RN60D
R108	Metal film, ¼ W, 1%, 1.21 k	Corn	RN60D
R111	Metal film, ¼ W, 1%, 27.4 Ω	Corn	RN60D
R112	Metal film, ¼ W, 1%, 3.32 k	Corn	RN60D
Transistors			
Q1,–4	Silicon	Sprague	TD101
Q5,Q6,Q15,Q16	Matched pairs, silicon	Fair	2N3640
Q7,Q8	Matched pair, silicon	Fair	2N3634
Q9,Q17,Q20,Q21,Q23, Q26,Q28	Silicon	Fair	2N3634
Q10,Q18,Q19,Q22,Q24, Q25,Q27,Q30,Q29	Silicon	Fair	2N3640
Q11,Q14,Q12,Q13	Matched pairs, silicon	Fair	2N3903



SINE CONVERTER BOARD (No. 141-017)

REFERENCE	DESCRIPTION	NAME	PART NUMBER
Capacitors			
C1,C5,C12,C13,C15,C19	Ceramic, 10 V, 0.1 μF	CRL	UK10-104
C2,C10,C11,C14	Elect, 15 V, 100 μF	Richey	16-375-100-15T
C17	Matched set, 5 x 2 μF	El Pac	ZX3022
C18	Ceramic, 1000 V, 5 pF	CRL	DD050
Diodes			
CR1,CR2	Silicon	Fair	FD6666
Integrated Circuits			
IC1–4	Six-diode unit	RCA	CA3039
IC5	Diode bridge	RCA	CA3019
Potentiometers			
R3,R8	250 Ω	A/B	FR251M
R16,R20,R46,R54	100 Ω	A/B	FR101M

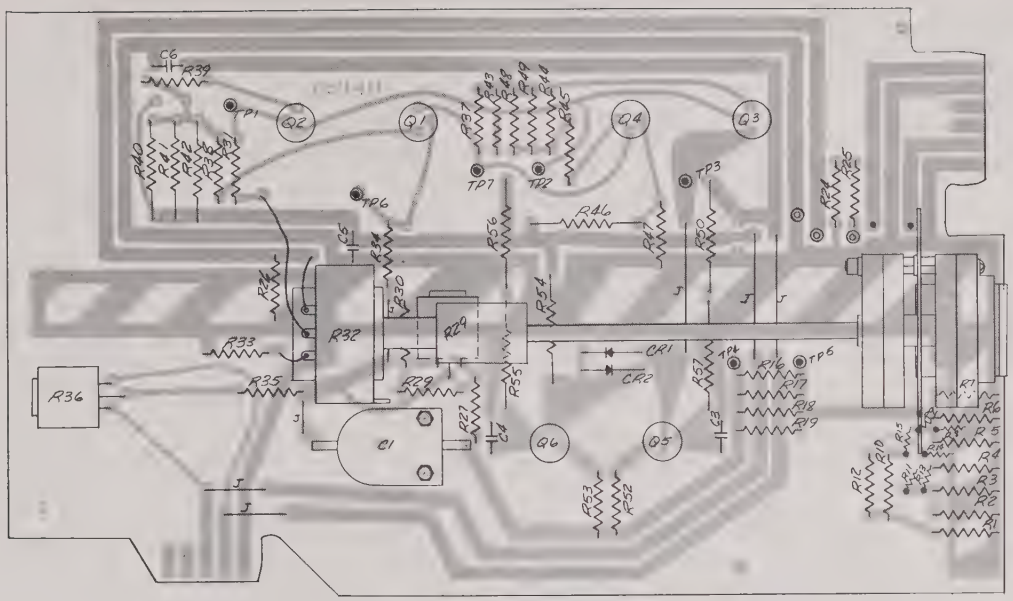
REFERENCE	DESCRIPTION	NAME	PART NUMBER
Resistors			
R1,R6,R10,R31,R35,R38,R43	Metal film ¼ W, 1%, 2 k	Corn	RN60D
R2,R7	Metal film, ¼ W, 1%,124 Ω	Corn	RN60D
R4,R5,R34,R37,R41,R42 R60,R61	Metal film, ¼ W, 1%, 7.5 k	Corn	RN60D
R9,R23,R58	Metal film, ¼ W, 1%, 1 K	Corn	RN60D
R11,R14	Metal film, ¼ W, 1%, 10 k	Corn	RN60D
R13,R15,R21	Metal film, ¼ W, 1%, 150 Ω	Corn	RN60D
R18	Metal film, ¼ W, 1%, 6.98 k	Corn	RN60D
R24	Metal film, ¼ W, 1%, 976 Ω	Corn	RN60D
R25	Carb, ½ W, 5%, 2.49 k	Corn	RN60D
R26,R28	Carb, ½ W, 5%, 15 Ω	Stack	RC20GF4R7J
R27,R63	Metal film, ¼ W, 1%, 21.5 Ω	Corn	RN60D
R32,R36	Metal film, ¼ W, 1%, 56.2 Ω	Corn	RN60D
R33	Metal film, ¼ W, 1%, 1.1 k	Corn	RN60D
R39,R44	Metal film, ¼ W, 1%, 42.2 Ω	Corn	RN60D
R40	Metal film, ¼ W, 1%, 1.62 k	Corn	RN60D
R45,R47,R48,R51,R53,R55	Metal film, ¼ W, 1%, 49.9 Ω	Corn	RN60D
R49,R57	Metal film, ¼ W, 1%, 453 Ω	Corn	RN60D
R50,R56	Metal film, ¼ W, 1%, 3.01 k	Corn	RN60D
R52	Metal film, ¼ W, 1%, 110 Ω	Corn	RN60D
R59	Metal film, ¼ W, 1%, 1.91 k	Corn	RN60D
R62	Carb, ½ W, 10%, 316 Ω	Stack	RC20GF151K
Transistors			
Q1,Q2	Matched pair, silicon	Fair	2N3646
Q3,Q4	Matched pair, silicon	Fair	2N3640
Q5	Silicon	Motorola	2N3299
Q6	Silicon	Motorola	2N2905



POWER REGULATOR BOARD (No. 141-014C)

REFERENCE	DESCRIPTION	NAME	PART NUMBER
Capacitors			
C1,C2,C7,C8,C13–18	Ceramic, 50 V, 0.01 μF	CRL	CK103
C3–6	Ceramic, 220 pF	CRL	DD221
C9,C11	Electrolytic, 15 V, 100 μF	Richey	16-375-100-15T
C10,C12,C19,C20	Ta, 15 V, 33μF	Sprague	196D33X0015FB
Diodes			
CR1,CR2,CR4,CR5, CR8,CR9	Silicon	Semtech	SCE-1
CR3,CR6,CR7	Silicon	Fair	FD6666
Integrated Circuits			
IC1–4	Operational Amplifier	Fair	μA709
Potentiometer			
R25	250 Ω	A/B	FR251M

REFERENCE	DESCRIPTION	NAME	PART NUMBER
Resistors			
R1,R2,R8,R11	Metal film, ¼ W, 1%, 3.01 k	Corn	RN60D
R3	Metal film, ¼ W, 1%, 9.53 k	Corn	RN60D
R4	Metal film, ¼ W, 1%, 3.16 k	Corn	RN60D
R5–7,R26,R27,R29–31	Carb, ½ W, 10%, 1.5 k	Stack	RC20GF152K
R9,R10,R13,R14,R33,R34 R36,R37	Carb, ½ W, 10%, 470 Ω	Stack	RC20GF471K
R12,R15,R22,R35,R38,R59	Carb, ½ W, 10%, 1 k	Stack	RC20GF102K
R16,R65,R66	Carb, ½ W, 5%, 3.9 Ω	Stack	RC20GF3R9J
R17,R20	Carb, ½ W, 10%, 220 Ω	Stack	RC20GF221K
R18,R19	Carb, ½ W, 10%, 2.7 k	Stack	RC20GF272K
R21,R58	Carb, ½ W, 10%, 3.9 k	Stack	RC20GF392K
R23,R32	Matched set to 0.1%, 3.01 k	Corn	RN60D
R24	Metal film, ¼ W, 1%, 124 Ω	Corn	RN60D
R28	Metal film, ¼ W, 1%, 2.87 k	Corn	RN60D
R39,R42	Wirewound, 5 W, 10%, 10 Ω	Stack	RC20GFPW5
R40,R41	Carb, ½ W, 10%, 10 k	Stack	RC20GF103K
R43	Metal film, ¼ W, 1%, 10 k	Corn	RN60D
R44	Metal film, ¼ W, 1%, 3.32 k	Corn	RN60D
R45	Metal film, ¼ W, 1%, 19.1 k	Corn	RN60D
R46	Metal film, ¼ W, 1%, 12.1 k	Corn	RN60D
R47,R52	Carb, ½ W, 10%, 2.2 k	Stack	RC20GF222K
R48,R51	Carb, ½ W, 10%, 12 k	Stack	RC20GF123K
R49,R50,R55,R56	Carb, ½ W, 10%, 100 Ω	Stack	RC20GF101K
R54	Carb, ½ W, 10%, 1.8 k	Stack	RC20GF182K
R57,R60	Metal film, ¼ W, 1%, 15 k	Corn	RN60D
R61,R64	Carb, ½ W, 10%, 680 Ω	Stack	RC20GF681K
R62,R63	Carb, ½ W, 10%, 22 k	Stack	RC20GF223K
Transistors			
Q1,Q3,Q5,Q10,Q12	Silicon	Fair	2N3646
Q2,Q4,Q6,Q11,Q14	Silicon	Motorola	MPS3638
Q7,Q13,Q25	Silicon	RCA	40250
Q8,Q15,Q28	Silicon	Fair	2N3740
Q16,Q18	Matched pair, silicon	Motorola	MPS3638
Q17,Q19	Matched pair, silicon	Fair	2N3642
Q20,Q23,Q24	Silicon	Fair	2N3642
Q22,Q26,Q27	Silicon	Fair	2N3905



POWER AMPLIFIER BOARD (No. 141-015A)

REFERENCE	DESCRIPTION	NAME	PART NUMBER
Capacitors			
C1	Variable, 4.5–25 pF	Erie	503-001-37A
C3,C4	Ceramic 50 V, 0.01 μF	CRL	CK103
C5,C6	Ta, 35 V, 27 μF	Sprague	K2R7W35
Diodes			
CR1,CR2	Silicon	Fair	FD6666
Potentiometers			
R29	100 Ω	A/B	FR101M
R32	100 Ω	Ohmite	CU1011
R36	100 k	A/B	FR104M
Resistors			
R1,R4–6	Metal film, ¼ W, 1%, 10 Ω	Corn	RN60D
R2,R3	Metal film, 1 W, 1%, 71.5 Ω	Corn	RN70D
R7,R30	Metal film, ¼ W, 1%, 61.9 Ω	Corn	RN60D
R8,R15	Metal film, ¼ W, 1%,46.4 Ω	Corn	RN60D
R9,R11,R13,R14	Metal film, ¼ W, 1%, 26.1 Ω	Corn	RN60D
R10,R12	Metal film, ¼ W, 1%, 15 Ω	Corn	RN60D
R16–19	Metal film, ¼ W, 1%, 200 Ω	Corn	RN60D

REFERENCE	DESCRIPTION	NAME	PART NUMBER
R20,R23	Metal film, ¼ W, 1%, 90.9 Ω	Corn	RN60D
R21,R22,R28,R38,R39	Metal film, ¼ W, 1%, 100 Ω	Corn	RN60D
R24,R25	Metal film, ¼ W, 1%, 31.6 Ω	Corn	RN60D
R26	Metal film, ¼ W, 1%, 24.9 Ω	Corn	RN60D
R27	Metal film, ¼ W, 1%, 825 Ω	Corn	RN60D
R31	Carb, ½ W, 5%, 200 Ω	Stack	RC20GF201J
R33	Metal film, ¼ W, 1%, 42.2 Ω	Corn	RN60D
R34	Carb, ½ W, 5%, 10 Ω	Stack	RC20GF100J
R35	Metal film, ¼ W, 1%, 10 k	Corn	RN60D
R37,R43	Metal film, ¼ W, 1%, 576 Ω	Corn	RN60D
R40–42	Metal film, ½ W, 1%, 2.49 k	IRC	RN65D
R44,R45,R52,R53	Carb, ½ W, 5%, 4.7 Ω	Stack	RN70D1001F
R46,R54	Carb, 1 W, 1%, 1 k	Corn	RC20GF102K
R47	Carb, ½ W, 5%, 150 Ω	Stack	RC20GF151J
R48,R49	Metal film, ¼ W, 1%, 316 Ω	Corn	RN60D
R50,R51,R55,R56	Carb, 2 W, 5%, 47 Ω	Stack	RC42GF470J
Switch Assembly			
T-105	Wafer, switch	CTS	T-105
Transistor			
Q1,Q2	Matched pair, silicon	Motorola	2N3299
Q3,Q4	Matched pair, silicon	Motorola	2N2905
Q5	Silicon	Motorola	2N3299
Q6	Silicon	Motorola	2N2905

LIST OF MANUFACTURERS

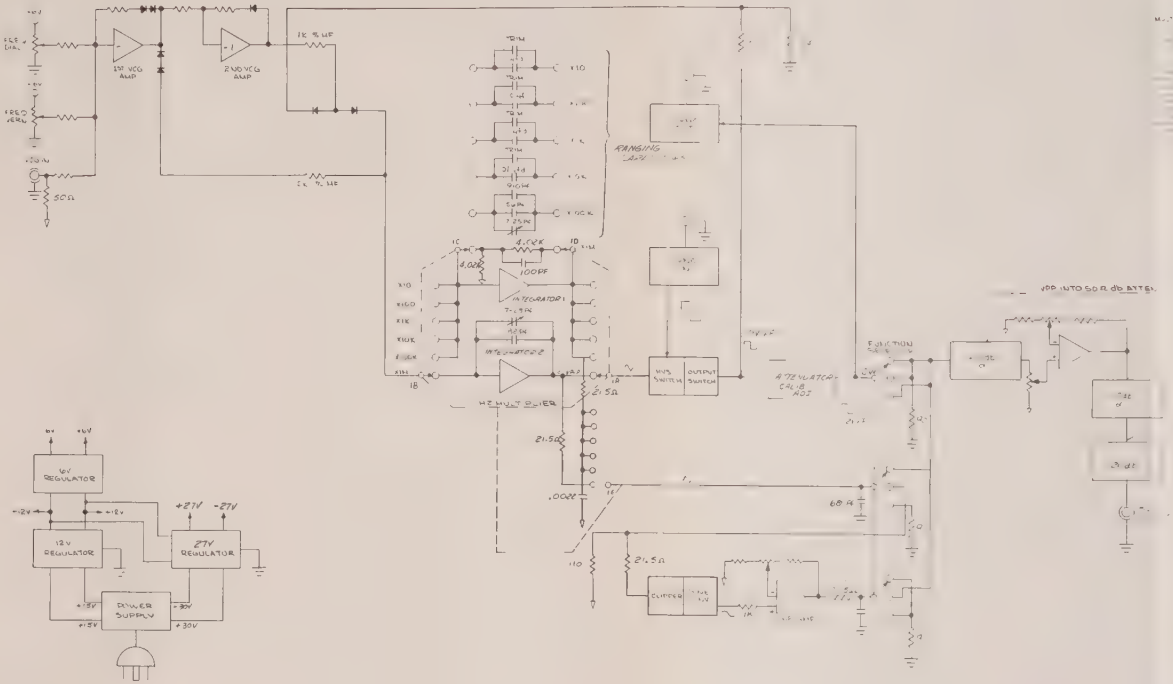
A/B	Allen Bradley, Milwaukee, Wisconsin
ARCO	Arco Electronics, Great Neck, L.I., New York
Corn	Corning Glass Works, Bradford, Pennsylvania
CRL	Centralab, Division of Globe-Union, Milwaukee, Wisconsin
CTS	Chicago Telephone Systems, Los Angeles, California
Elpac	Elpac Incorporated, Fullerton, California
Erie	Erie Technological Products Inc., Erie, Pennsylvania
Fair	Fairchild Semiconductor Corporation, Palo Alto, California
IBM	IBM Industrial Products, White Plains, New York
IRC	IRC Inc., Philadelphia, Pennsylvania
Littelfuse	Littelfuse Inc., Des Plaines, Illinois
Motorola	Motorola Semiconductor Products, Phoenix, Arizona
Mura	Mura Corp., Great Neck, L.I., New York
RCA	RCA Semiconductor Division, Somerville, New Jersey
Richey	Richey Electronics, Nashville, Tennessee
Semtech	Semtech Corporation, Newbury Park, California
Sprague	Sprague Electric Company, North Adams, Massachusetts
Stack	Stackpole Carbon Company, St. Marys, Pennsylvania
USECO	USECO Inc., Mt. Vernon, New York

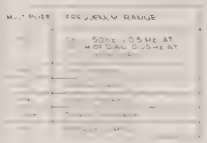
SECTION 6
DIAGRAMS

LIST OF DRAWINGS

This section contains the necessary drawings and diagrams for maintaining the Model 141 Function Generator. The drawings in this section are arranged in the following sequence:

Name	Schematic No.
Model 141 Outline Drawing	141-601
Model 141 Block Diagram	141-600
Mother Board, Schematic Diagram	141-218
Subpanel Board, Schematic Diagram	141-216
Main Board, Schematic Diagram	141-212
Sine Converter Board, Schematic Diagram	141-217A
Power Regulator Board, Schematic Diagram	141-214A
Power Amplifier Board, Schematic Diagram	141-215





unless otherwise specified ± 0 .X ± 0.1 .XX ± 0.05	rev		by	date	apd
	WAVETEK san diego, calif				
scale	by	date 7-9-68	app		
material	title BLOCK DIAGRAM				
finish	model no 141	dwg no 141-600		rev	

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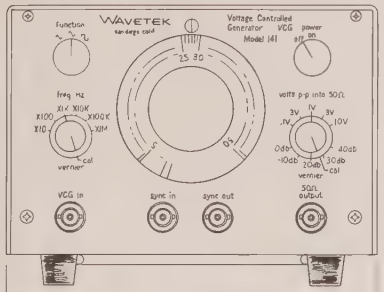

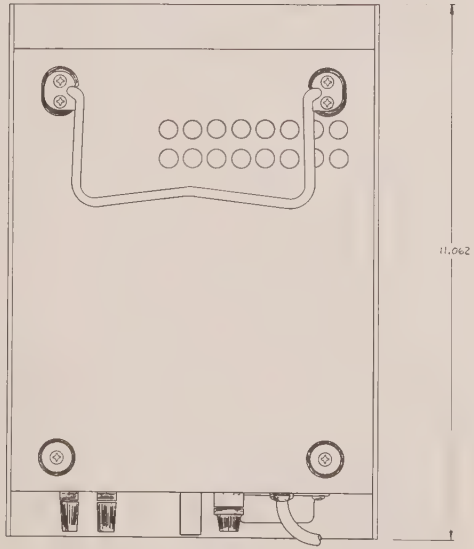

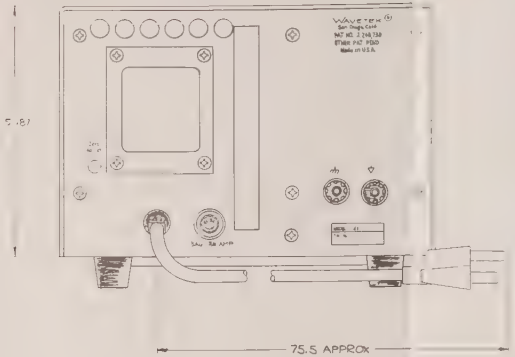

rev		by	date	apr
XXX ± .010 XX ± .030	WAVETEK san diego, calif			
scale 1/	by DWEIAND	date 5.80.69	apr	
material N/A	title OUTLINE DRAWING			
finish N/A	model no 41	dwg no 141-601	rev	

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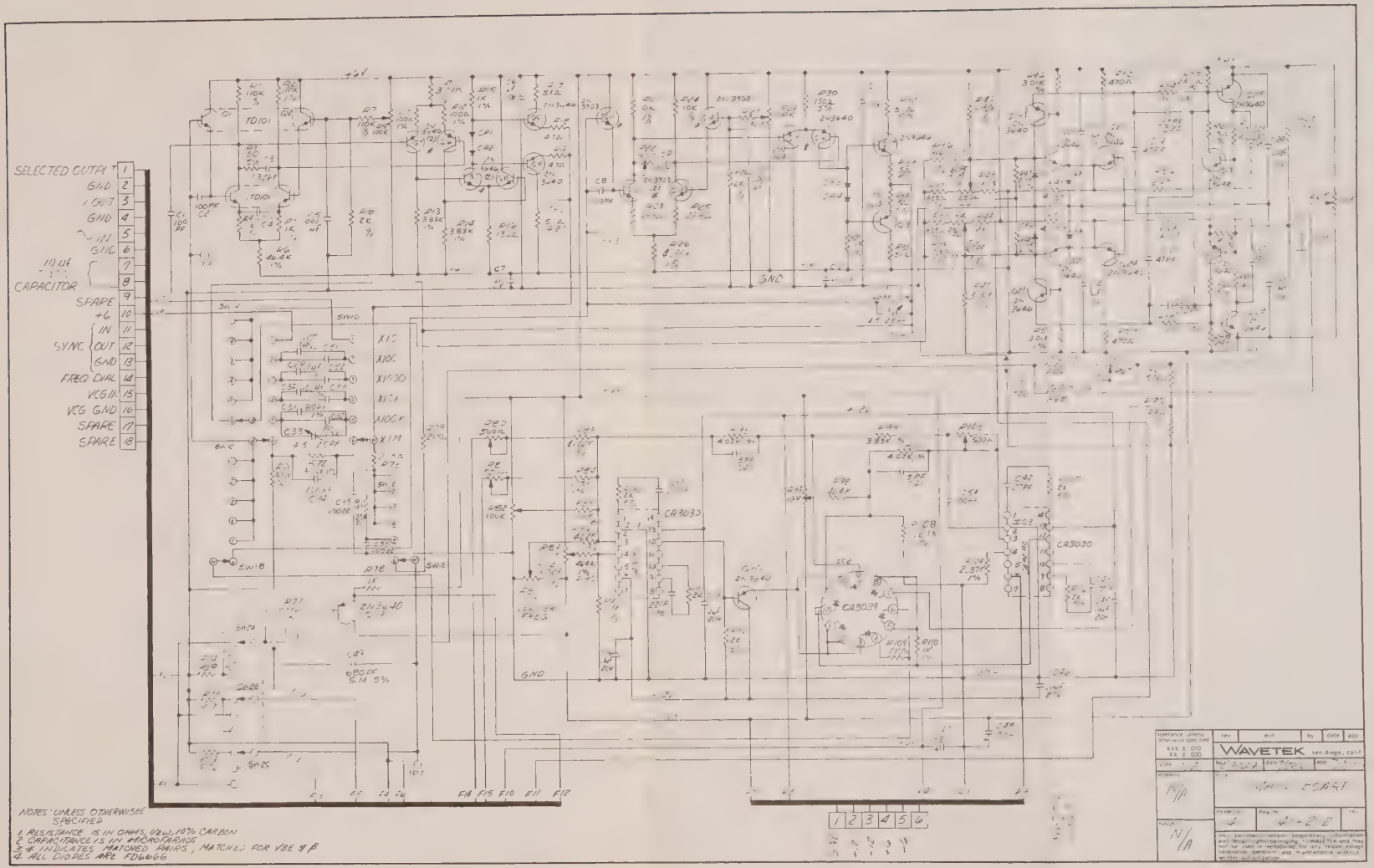
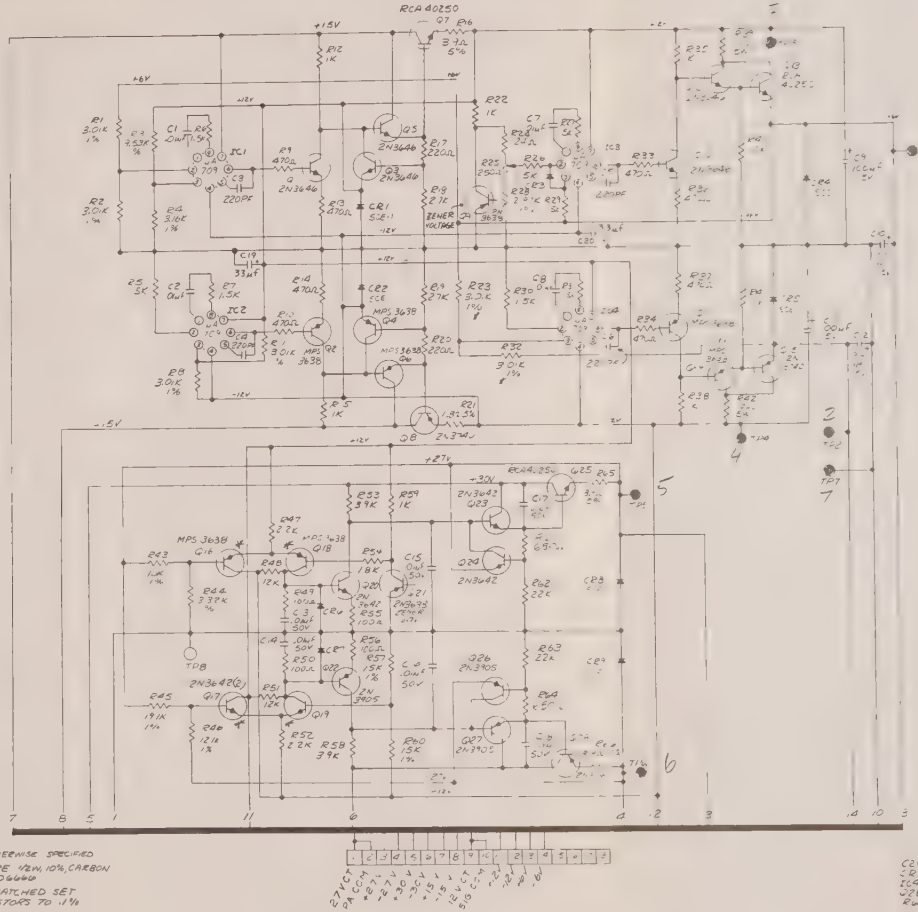
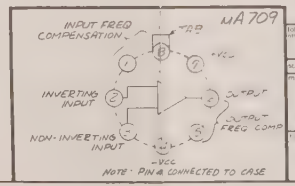

SELECTED OUTPUT
GND
OUT
GND
IN
GND
10 uf
CAPACITOR
SPARE
+6
SYNC IN
SYNC OUT
SYNC GND
FREQ DIAL
VCG IN
VCG GND
SPARE
SPARE
+6V
GND
CA3039
CA3030
2N3640
2N3904
2N3906
2N3903
TD101
SW-D
SW-B
SW-E
SW-A
SW-C
X1C
X10C
X100
X1K
X10K
X1M
NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTANCE IS IN OHMS, 1/2W, 10% CARBON
2. CAPACITANCE IS IN MICROFARADS
3. # INDICATES MATCHED PAIRS, MATCHED FOR VBE & β
4. ALL DIODES ARE FD6666
WAVETEK
san diego, calif
SCHEMATIC



NOTES UNLESS OTHERWISE SPECIFIED
1 RESISTORS ARE 1/2W, 10%, CARBON
2 DIODES ARE FDG666
3 ⊕ INDICATES MATCHED SET
4 ✱ MATCHE: RESISTORS TO .1%



tolerance unless otherwise specified: XXX ± .010, XX ± .030	rev	ecn	by	date	app.
scale N/A	drawn P. Palmer	date 9-8-68	app.		
material N/A	title SCHEMATIC POWER REGULATOR				
finish N/A	model 141	dwg 141-214			rev A

WAVETEK san diego, calif.

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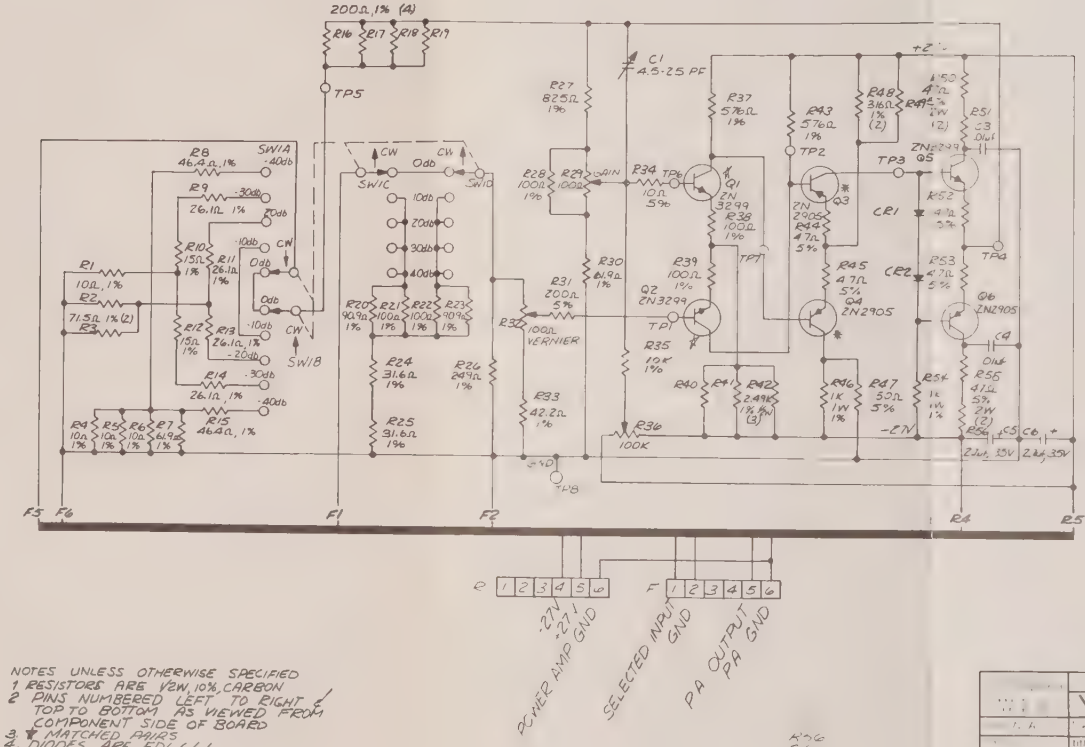

NOTES UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE ½W, 10%, CARBON
2. PINS NUMBERED LEFT TO RIGHT & TOP TO BOTTOM AS VIEWED FROM COMPONENT SIDE OF BOARD
3. ✱ MATCHED PAIRS
4. DIODES ARE FDG666
5. ✱ MEDIUM TO LOW BETA MATCHED PAIR

R26
C6
CR2
Q6

WAVETEK san diego, calif

N/A

title SCHEMATIC DIAGRAM POWER AMPLIFIER

4 14-215

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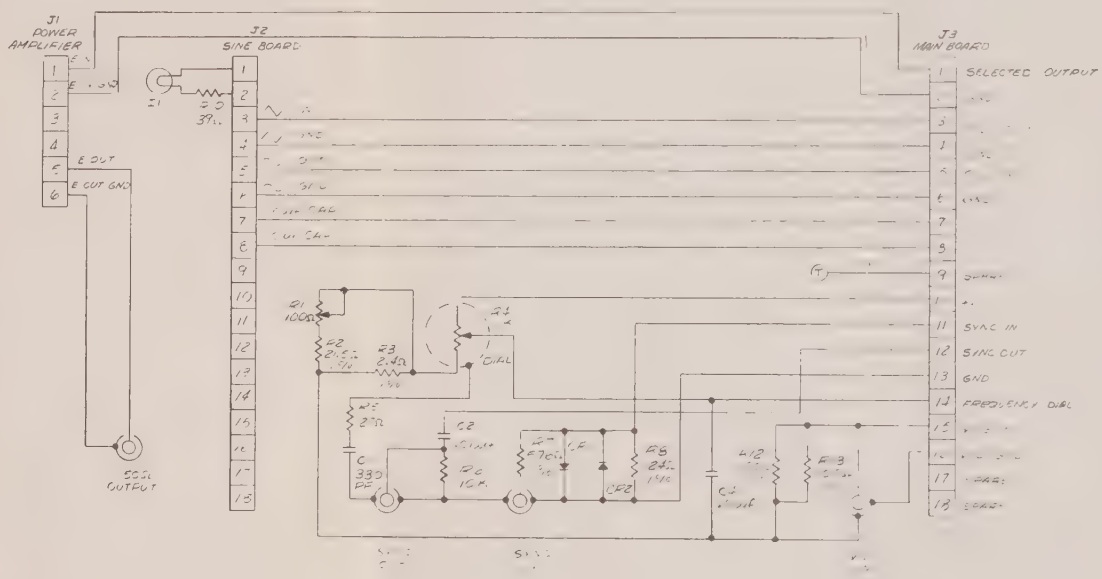

NOTES: UNLESS OTHERWISE SPECIFIED
1 DIODES ARE FDG266
2 RESISTANCE IS IN OHMS 1/2W, 10% CARBON

tolerance unless otherwise specified XXX ± .010 XX ± .030			WAVETEK san diego, calif
scale N/A	by E. HOLAMA	date 11/20/63	
material N/A	title SUB PANEL BOARD		
finish N/A	model no 14	dwg no 14!-216	

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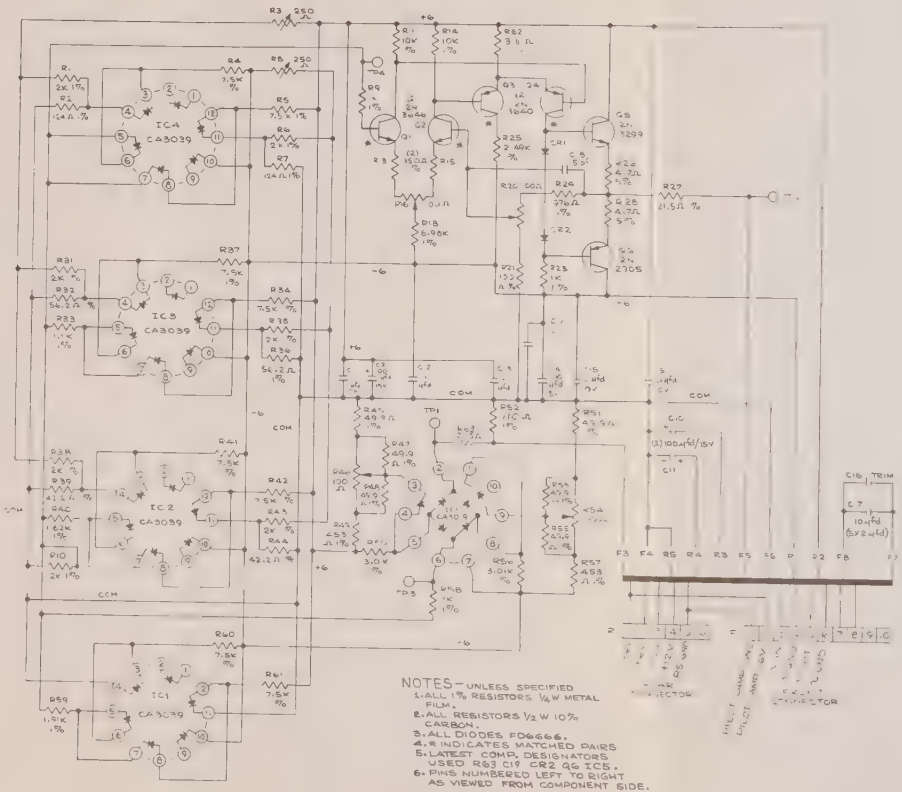

NOTES – UNLESS SPECIFIED
1. ALL 1% RESISTORS ¼W METAL FILM.
2. ALL RESISTORS ½W 10% CARBON.
3. ALL DIODES FD6666.
4. ✱ INDICATES MATCHED PAIRS
5. LATEST COMP. DESIGNATORS USED R63 C19 CR2 AG ICS.
6. PINS NUMBERED LEFT TO RIGHT AS VIEWED FROM COMPONENT SIDE.

rev	ecn	by	date	apd
B	R14 was 237Ω	JAC	4/1/68	
A	REDRAWN	JAC	10/30/68	

Tolerance unless otherwise specified: XXX ± 010, XX ± 030

WAVETEK san diego ca if

scale N/A | DR L. ADAMSON | date 10/30/68 | acc

material: N/A

Title: SINE CONVERTER

finish: N/A

model no 141 | dwg no 141-217 | rev A

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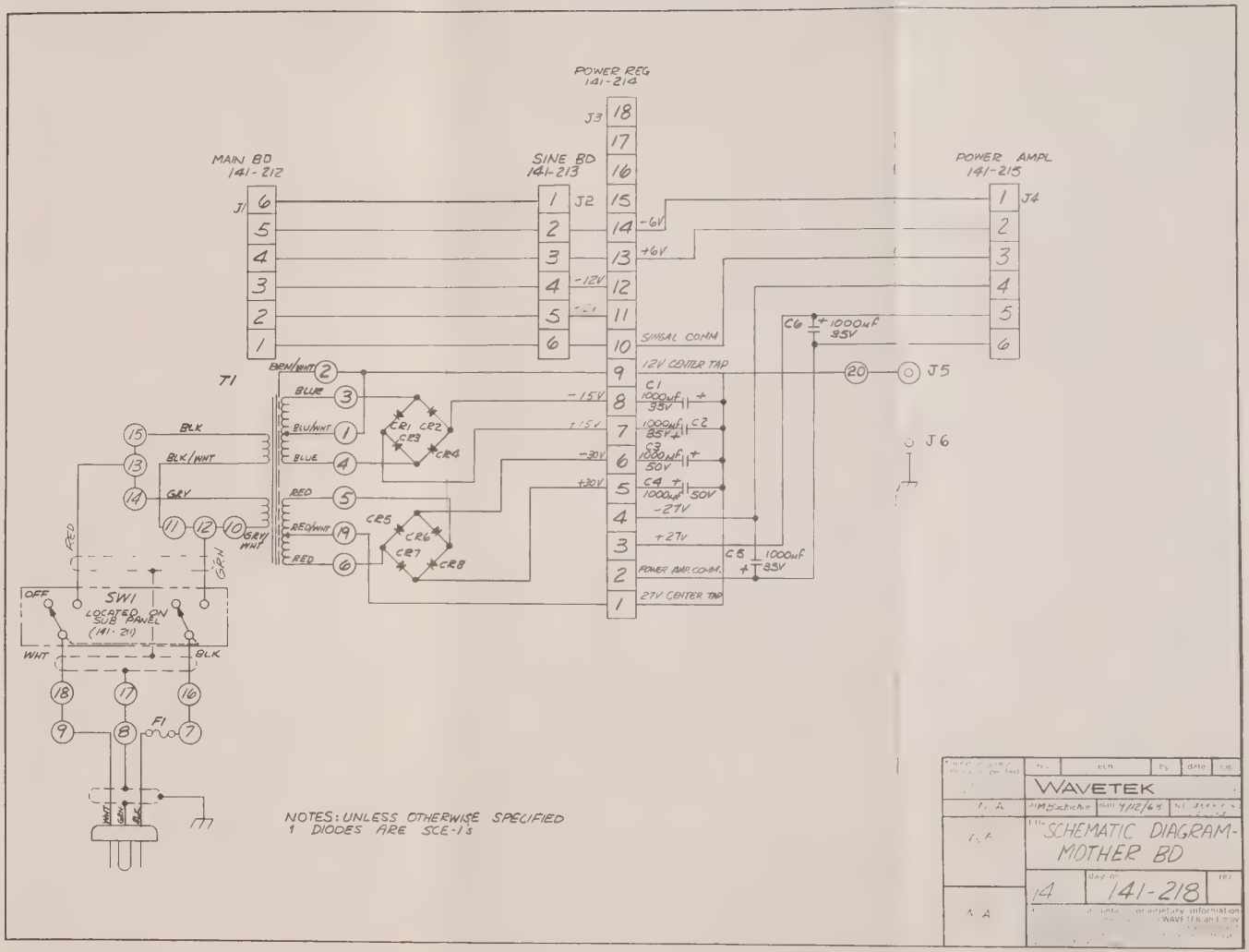
POWER REG
141-214
MAIN BD
141-212
SINE BD
141-213
POWER AMPL
141-215
J1
J2
J3
J4
J5
J6
T1
SW1
LOCATED ON
SUB PANEL
(141-211)
OFF
F1
C1
C2
C3
C4
C5
C6
CR1
CR2
CR3
CR4
CR5
CR6
CR7
CR8
-6V
+6V
-12V
SINEAL COMM
12V CENTER TAP
-15V
+15V
-30V
+30V
-27V
+27V
POWER AMP COMM.
27V CENTER TAP
1000mF
35V
50V
BRN/WHT
BLUE
BLU/WHT
RED
RED/WHT
BLK
BLK/WHT
GRY
GRY/WHT
GRN
WHT
NOTES: UNLESS OTHERWISE SPECIFIED
1 DIODES ARE SCE-1's
WAVETEK
SCHEMATIC DIAGRAM-
MOTHER BD
141-218

SECTION 7
DIFFERENCE DATA

INTRODUCTION

The WAVETEK product-improvement program insures that the latest electronic developments are incorporated into the WAVETEK instruments by the addition of circuit and component improvements as rapidly as development and testing permit.

Due to the time required to document and print these Instruction Manuals, it is not always possible to get the changes incorporated into the manual. In this case, the changes to the basic model, described in Sections One through Six, are listed in the following **Difference Data**. If no such information follows, the manual is correct as printed.

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